THE EVALUATION OF SEEDBEDS, METHOD OF SEEDING, AND SPECIES FOR RESEEDING ARID RANGELANDS OF ARIZONA

Pima, Congress, and Fredonia Areas

A Progress Report for the Calendar Year

1964

submitted to

The Bureau of Land Management
United States Department of the Interior

prepared by

The Department of Watershed Management
Agricultural Experiment Station
University of Arizona

THE EVALUATION OF SEEDBEDS, METHOD OF SEEDING, AND SPECIES FOR RESEEDING ARID RANGELANDS OF ARIZONA

Pima, Congress, and Fredonia Areas

A Progress Report for the Calendar Year

1964

submitted to

The Bureau of Land Management
United States Department of the Interior

prepared by

The Department of Watershed Management
Agricultural Experiment Station
University of Arizona

INTRODUCTION

This is a progress report for the calendar year 1964 presenting results from experimental range-seeding studies. These studies were located at three areas in Arizona -- Congress, Pima and the Arizona Strip near Fredonia. At each of the areas, several methods of seedbed preparation and brush control were tested with different times and methods of seeding various range grasses. These areas differed from each other in several significant aspects such as vegetation, climate, and soils. As a consequence, range seeding studies were varied to suit the respective areas. This is reflected in the nature of the experimental studies at each of these sites; and therefore, the results will be presented according to the individual area. However, the objectives of this project are common to all areas and they are as follows:

(1) To evaluate seedbed preparations and methods of seeding in order to more effectively revegetate the range type under study.

(2) To evaluate both chemical and mechanical methods of shrub control.

(3) To select those forage species which are best adapted to the particular range type.

(4) To determine, by use of appropriate instrumentation, the micro-environmental conditions limiting the germination, growth, and establishment of grass seedlings.

This report includes the geography, the legal description, the native vegetative aspects, and a brief climatic and edaphic description of each area. Data from recording-type rain gauges and hygrothermographs, maintained at each area, were used to determine the climatic effects on the various seedings. Permanent photo plots were established for each area. To protect

experimental seedings from rabbit and rodent damage, a combination of poisoned salt licks, fire arms, and in certain areas rabbit-proof fencing was used.

The terminal results from experimental seedings of pelleted and non-pelleted seed are appended to this report. During 1964 the final plant counts were taken on seedings of pelleted seed sown in 1961, 1962 and 1963. These counts bring to completion the experimental work with pelleted seed and the data therefrom complement the current project concerning the evaluation of seedbeds.

THE CONGRESS AREA

This area lies at an elevation of 3,000 feet and is situated approximately 13 miles west of Congress in West-central Arizona. The slope of the study area ranges up to 3%. The area lies on a flood plain at the base of the small Date Creek Mountain range. The soil of the area is a deep sandy loam, but it does not have a calcareous hardpan characteristic of many soils of arid regions. This area is situated in Section 4, T 10 N, R 7 W, Gila and Salt River Meridian.

To more adequately characterize the area under study, a survey of the existing vegetation was made. The percentage cover and density of all species in this area are presented in Table 1. Cover was determined by the variable plot method, and density was determined by the average number of plants per 100 square feet. Both determinations were made from 30 randomly selected points on the 1964 experimental area.

This survey of the vegetation points out the sparse cover of shrubs and grass in the Congress area. The coverage ranged from 2 to 3% and consisted mainly of mesquite (Prosopis juliflora) and creosotebush (Larrea

Table 1. The density of plants per acre and the percentage cover of native vegetation on the range reseeding area at Congress in 1964.

Species	Percentage Cover	Density
Mesquite (Prosopis juliflora)	1.07	29.0
Creosotebush (Larrea divaricata)	0.67	58.0
Catclaw (Acacia greggii)	0.03	
Joshua-tree (Yucca brevifolia)	0.17	
Baccharis (Baccharis sarothroides)	0.03	
Wolf-berry (Lysium californicum)	0.30	43.5
Cane cholla (Opuntia thornberi)	0.10	14.5
Tobosa (Hilaria mutica)	0.0	2018.3
Snakeweed (Gutierrezia sarothrae)	0.0	392.0
TOTAL	2.37%	

divaricata). Other species of minor importance were Joshua-tree (Yucca brevifolia), cane cholla (Opuntia thornberi), prickly pear (O. engelmannii), tobosa (Hilaria mutica), and snakeweed (Gutierrezia sarathrae).

The mean annual precipitation is estimated from the weather stations at Wickenburg and Aguila which have 10.88 and 9.33 inches, respectively. Approximately half of this precipitation occurs during the summer from July through September. The temperature during the summer period often rises above 100° F. and very low relative humidities are common in late spring and early summer.

The location of the 1964 study area and the proposed areas for future study are shown in Figure 1. The plot diagram for the 1964 studies are shown in Figure 2. The plot size was 0.46 acre. The combination of seedbed treatments and seeding variables shown on these plots in Figure 2 consist of the following major factors:

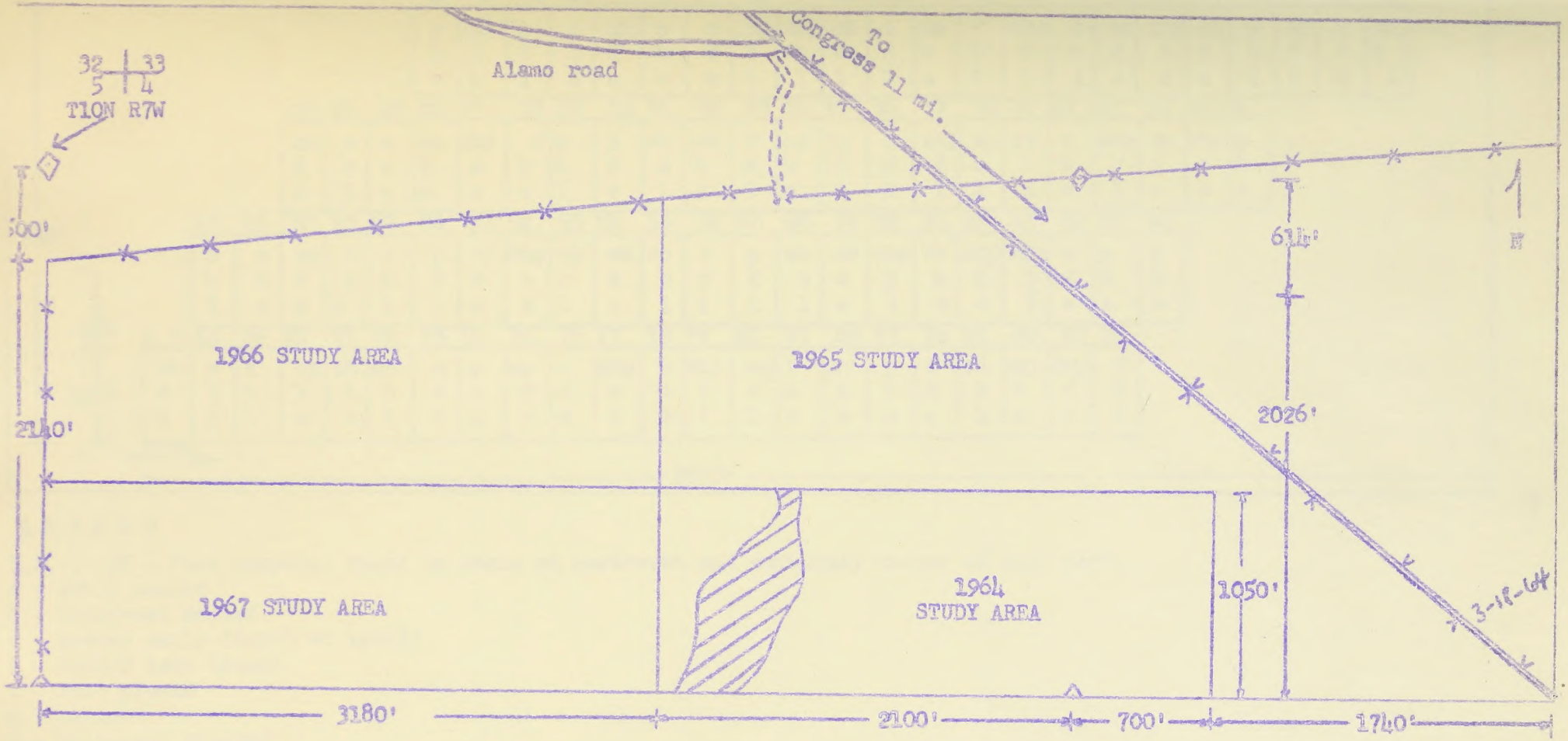
(1) March vs. late June seeding

(2) Broadcasting vs. drilling

(3) A comparison of double chaining, bulldozing, pitting, and root-plowing as brush removal seedbed preparation methods.

The experimental design was a complete-randomized block with four replications.

Because the basic factor affecting the success of a range seeding in this area is moisture, the results from this year's studies are particularly pertinent. There was not sufficient rain to obtain a satisfactory stand of grass on any of the treatments; however, the limited grass stand that was produced resulted only from the more effective seedbeds. The total rainfall from March through September was 3.08 inches. Of this amount 0.87 inches fell in March and this was not available for growth of the "warm-season"



Scale 1:772

L E G E N D

Barbed wire fence along U.S. Hwy. 93

Barbed wire fence

Gate in barbed wire fence

Graded road

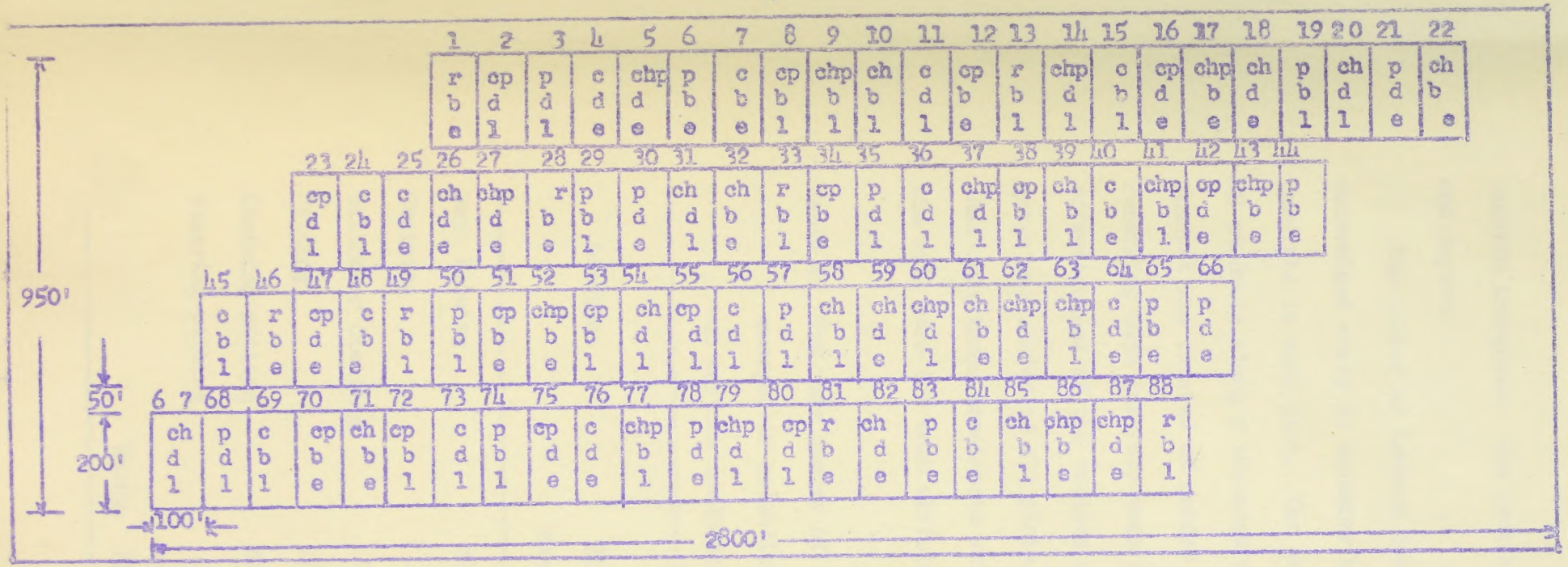
Inaccessible area (gullies)

Unimproved road

Section corner

¼ corner

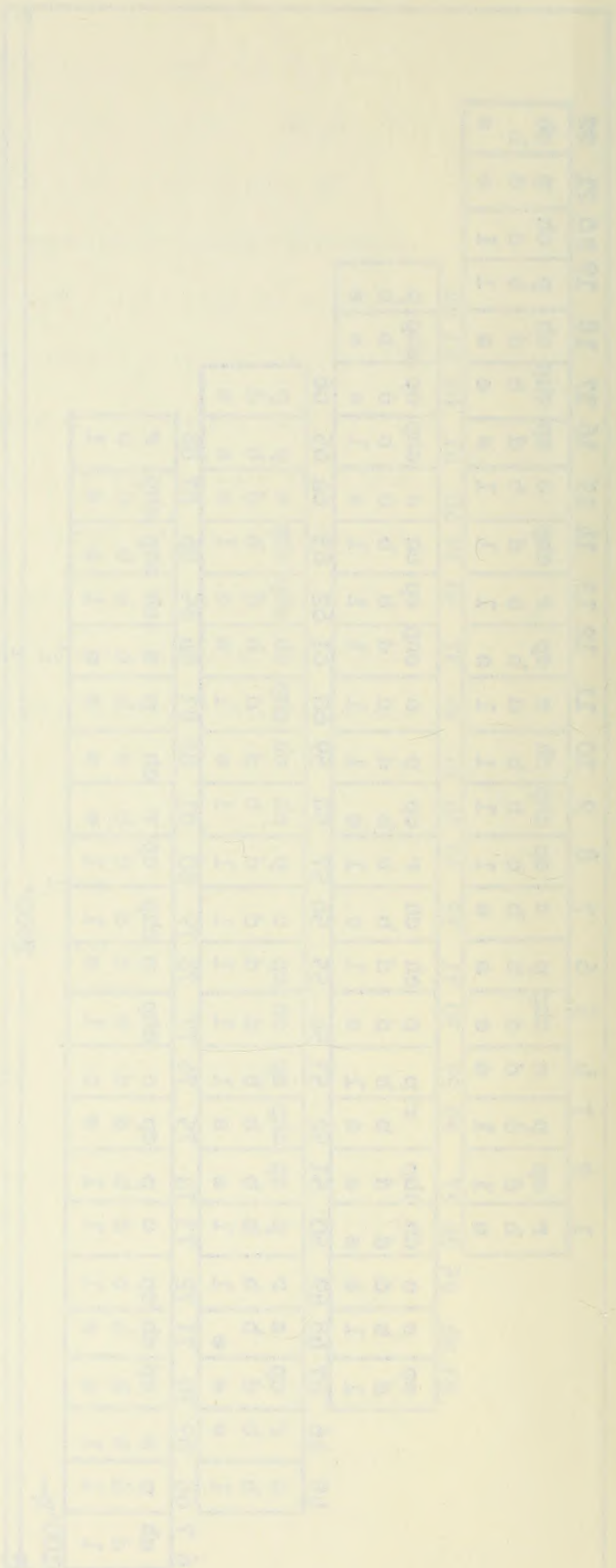
Figure 1 . Disposition of the studies planned at Congress for 1964, 1965, 1966, and 1967.



LEGEND

1,2,....88 - Plot numbers; found on stake at northwest and southeast corner of each plot.
d - drill seeded
b - broadcast seeded
e - seeded early (March or April)
l - seeded late (June)
r - root plowed
p - pitted
c - bulldozer cleared
ch - chained
cp - bulldozer cleared-pitted
chp - chained-pitted

Figure 2. Plot layout of 1964 Congress study.



lehmann lovegrass. The remainder (2.21 inches) fell almost entirely in July and August.

The number of lehmann lovegrass plants emerging after these rains was determined early in November by counting the plants in 10 one by five-foot quadrats in each plot. The counting procedure consisted of placing the 10 quadrats along a transect down the center of each plot. The first quadrat was located at random on the forepart of this transect; and the remaining nine quadrats were placed at 10-foot intervals. To measure the effectiveness of the various seeding variables and seedbeds, lehmann lovegrass was seeded on all plots. The results from this count clearly indicate that only those treatments which facilitated the penetration of rain into the soil were the most efficient (Table 2).

Table 2. The mean number of lehmann lovegrass plants per 200 square feet emerged or established with different times and methods of seeding on various seedbeds at Congress during 1964.

Seedbeds	Time and Method of Seeding				
	Broadcasting		Drilling		Means for Seedbeds
	March	June	March	June	
Root Plowing	39	44			41.5
Chaining	0	0	0	0	0
Bulldozer Clearing	0	0	9	1	2.5
Pitting	19	17	120	100	64
Chaining-pitting	62	27	87	2	44.5
Clearing-pitting	2	11	106	37	39
Means:	20.3	16.5	64.4	23.3	

The effective seedbed treatments were root plowing, pitting, and pitting in combination with chaining or bulldozer clearing. In contrast, chaining and bulldozer-clearing, as individual treatments, did not promote the germination and growth of lehmann lovegrass. This was attributed to excessive run-off from these seedbeds. The mean values (Plants per 200 square feet) for method of seeding and time of seeding are as follows:

Broadcasting	19.2
Drilling	43.2
Early seeding (March)	40.3
Late seeding (June)	19.9

As is normally the case under the more xeric environmental conditions, drilling was more effective than broadcasting as a seeding method. These results indicate also that time of seeding may be a deciding factor in promoting a successful range seeding in unfavorable years. The early seeding from both drilling and broadcasting during March promoted a much better stand establishment than the June seeding.

The means for seedbeds in Table 2 indicate that rootplowing, pitting, and pitting in combination with chaining and bulldozer clearing should be included in future studies. On the other hand, chaining and bulldozer-clearing are not adequate seedbed preparations and probably should not be included in future studies unless supplemental pitting treatments are included.

In addition to the seeding studies just discussed, a species adaption nursery was established. This study is located adjacent to plot 19 (Figure 2) on the north side. Two rows of each species are marked with a numbered stake located at the end of the rows and centered between the rows. These species were seeded on an area that had been pitted early in April. The

species and their identifying row number are listed in Table 3.

Table 3. Species of range grasses seeded at Congress in June, 1964.

Row Number	Species
1.	Black grama (Bouteloua eriopoda)
2.	Blue grama (B. gracilis)
3.	Hairy grama (B. hirsuta)
4.	Turkestan bluestem (Andropogon ischaemum)
5.	Arizona cottontop (Trichachne californica)
6.	Plains bristlegrass (Setaria macrostachya)
7.	Bush muhly (Muhlenbergia porteri)
8.	Boer lovegrass (Eragrostis chloromelas)
9.	Wilman lovegrass (E. superba)
10.	Plains lovegrass (E. intermedia)
11.	Sideoats grama (Bouteloua curtipendula)
12.	Sand dropseed (Sporobolus cryptandrus)
13.	Creeping dropseed (S. usitatus)
14.	Spike dropseed (S. contractus)
15.	Pretoria panicgrass (Panicum coloratum)
16.	Blue panicgrass (P. antidotale)
17.	Vine mesquite (P. obtusum)
18.	Hall's panicgrass (P. hallii)

There was no emergence of any of the species in 1964. These species will be observed through next year to note any delayed germination if more favorable conditions prevail.

THE PIMA AREA

This area lies at an elevation of 3,100 feet northwest of Pima in an area known locally as Mesquite Well. It is located in Sections 10 and 15, T 6 S, R 23 E, Gila and Salt River Meridian. The study area lies on a terrace of coarse granitic soils. The terrain slopes gently to the east and the slope ranges from about 2 to 5%. The average annual rainfall is estimated to be 10 inches which is about equally divided between summer and winter.

A survey of the native vegetation was also made at Pima by the same procedures used at Congress. The results of this survey are presented in Table 4. They illustrate that the Pima Area has about four times more cover than the Congress area. The components of this vegetative cover (11.1%) are mainly creosotebush (5.9%), mesquite (2.4%) and whitethorn (1.3%). Aside from bush muhly (Muhlenbergia porteri), there were no perennial grasses.

The location of the 1964 study area at Pima and the proposed areas for future study are shown in Figure 3. The plot diagram for the 1964 studies is shown in Figure 4.

The combinations of seedbed preparations and seeding variables used in these studies consist of the following major factors:

(1) March vs. late June seeding

(2) Broadcasting vs. drilling

(3) A comparison of chaining, bulldozer clearing, and rootplowing as brush removal-seedbed preparation methods.

The experimental design was a complete-randomized block with four replications. The plot size was 0.46 acres. To measure the effectiveness

Table 4. Density of plants per acre and percentage cover of the native vegetation occurring in 1964 on the Pima range reseeding site.

Species	Percentage Cover	Density
Mesquite (*Prosopis juliflora*)	2.4	72.6
Creosotebush (*Larrea divaricata*)	5.93	130.7
Catclaw (*Acacia greggii*)	0.17	14.5
Whitethorn (*A. constricta*)	1.37	87.1
Burroweed (*Aplopappus tenuisectus*)	0.10	1147.0
Baccharis (*Baccharis pteronoides*)	0.23	145.2
Wolfberry (*Lycium californicum*)	0.07	14.5
Cane cholla (*Opuntia thornberi*)	0.10	14.52
Ephedra (*Ephedra trifurca*)	0.57	101.64
Yucca (*Yucca elator*)	0.17	14.52
Bush muhly (*Muhlenbergia porteri*)	0.03	
Fluffgrass (*Tridens pulchellus*)		261.3
TOTAL	11.14%	

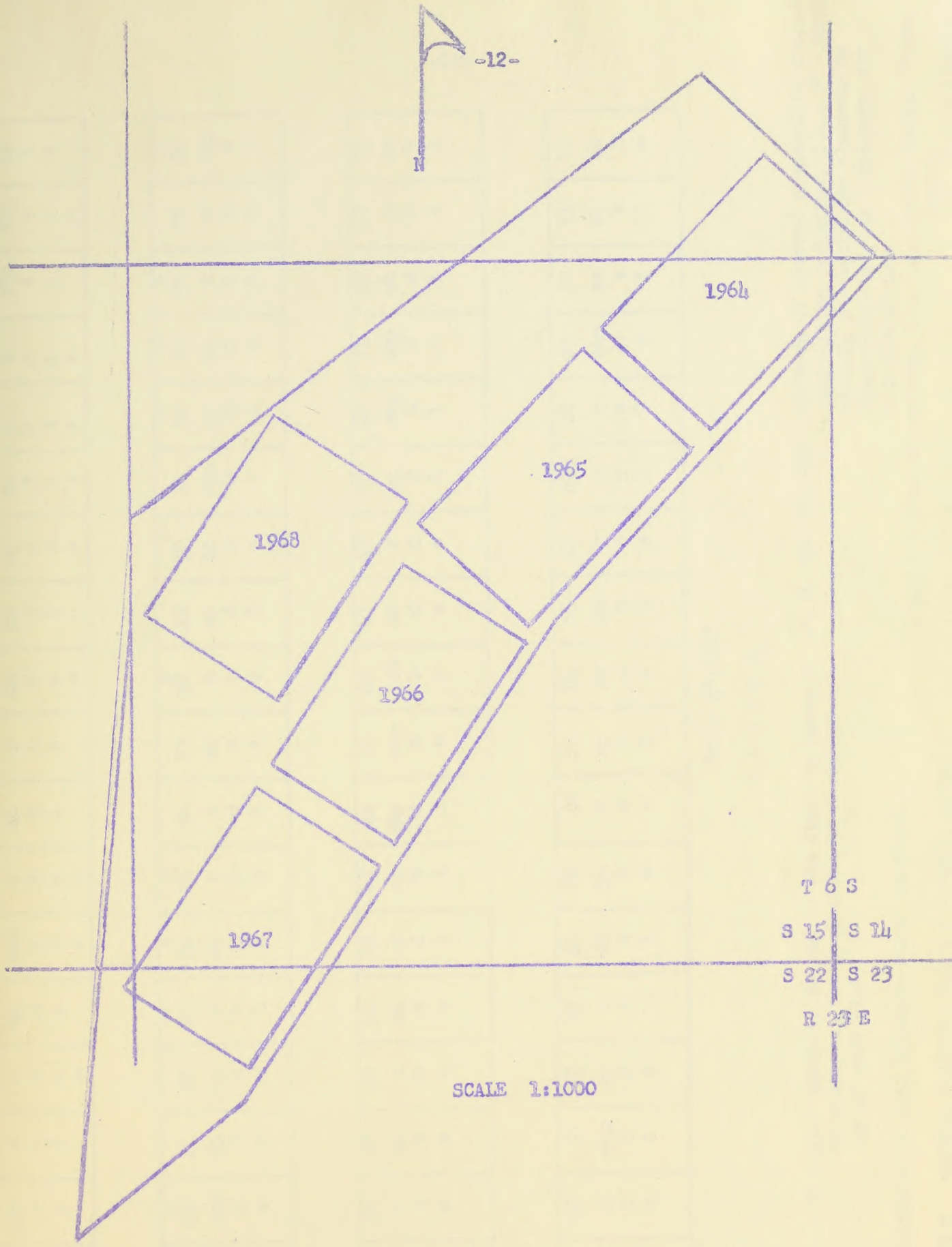
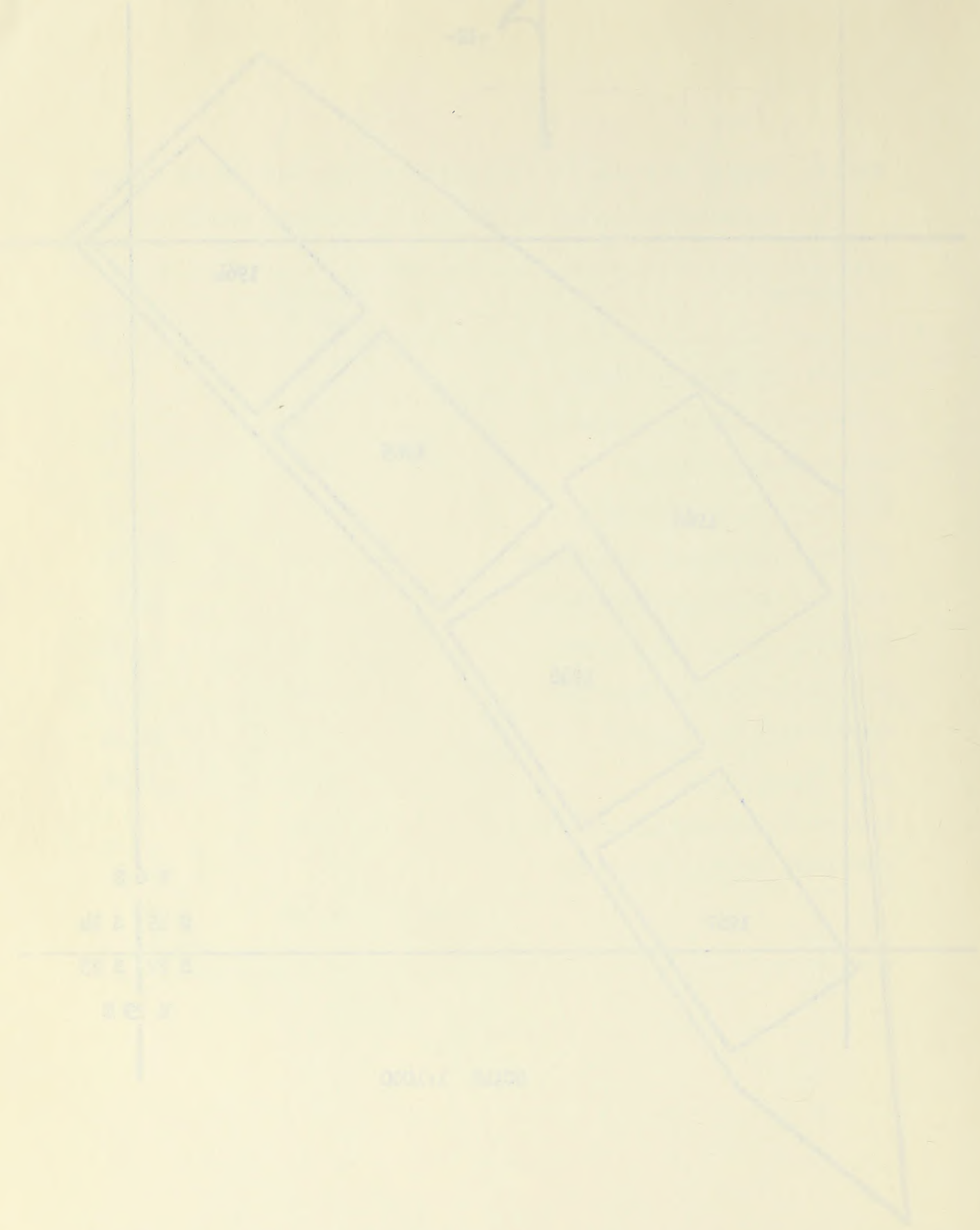
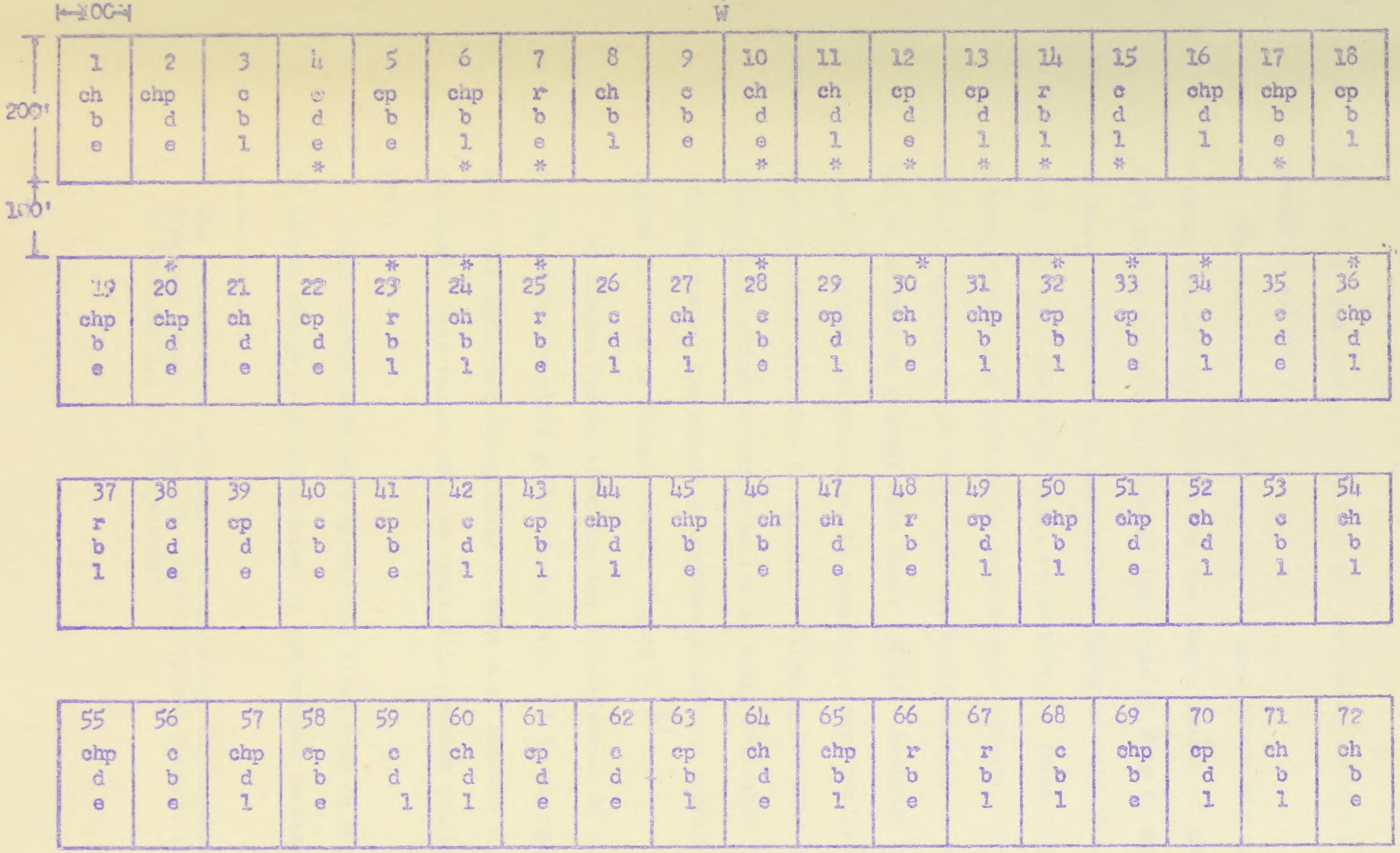


Figure 3. Disposition of the study sites in the Pima experimental area with respect to the area as a whole.





Scale $\frac{1}{2}$":100'

L E G E N D

1,2.....72 - plot numbers; marked in the field by numbers on stakes at the southwest and northeast corner of each plot.

* - Location of soil moisture block stations.

d and b - seeding methods, i.e., d - drill seeded
b - broadcast seeded

r, c, cp, ch, chp - methods of seedbed preparation and/or competition reduction, i.e., r - root plowed; c - bulldozer cleared; cp - cleared-pitted; ch - chained; chp - chained-pitted.

e and l - Time of seeding, i.e., e - early seeded (March or April).
l - late seeded (June).

Figure 4. Plot layout of the 1964 Pima study.

of the various seeding variables and seedbeds, lehmann lovegrass was seeded on all plots.

The results from this seeding are more adequately explained by first viewing the rainfall pattern for the summer season of growth. A total of 6.98 inches of rain fell between the dates of July 21 and October 17. Two of these rainstorms were particularly heavy on July 30 and September 11 when 1.75 and 1.20 inches fell, respectively. These rains occurred within 2-hour periods and resulted in considerable run-off. If it is assumed that rains in excess of 0.8 inches per two hours results in run-off, 1.35 inches can be assumed as run-off from these storms. Although this is an estimate based on visual observations, it presents a more realistic picture of the precipitation available for growth. Allowing for this estimated run-off leaves 5.63 inches of precipitation as being available for replenishing soil moisture. The actual precipitation and the resulting effective precipitation for Pima is illustrated in Figure 5. 1/

An unknown factor affecting the effectiveness of this precipitation is the coarse granitic soils of the area. It is suggested that these soils may aggrevate the aridity of this area because of a low-water holding capacity. This factor will be studied in greater detail in the forthcoming year.

Plant counts were made during the first week in November on the number of plants emerged and established in the various seedbeds. The counting

---

1/ The estimation of effective precipitation is discussed in the 1964 Progress Report to the BLM entitled "Brush Control and Revegetation on Southern Arizona Rangelands".

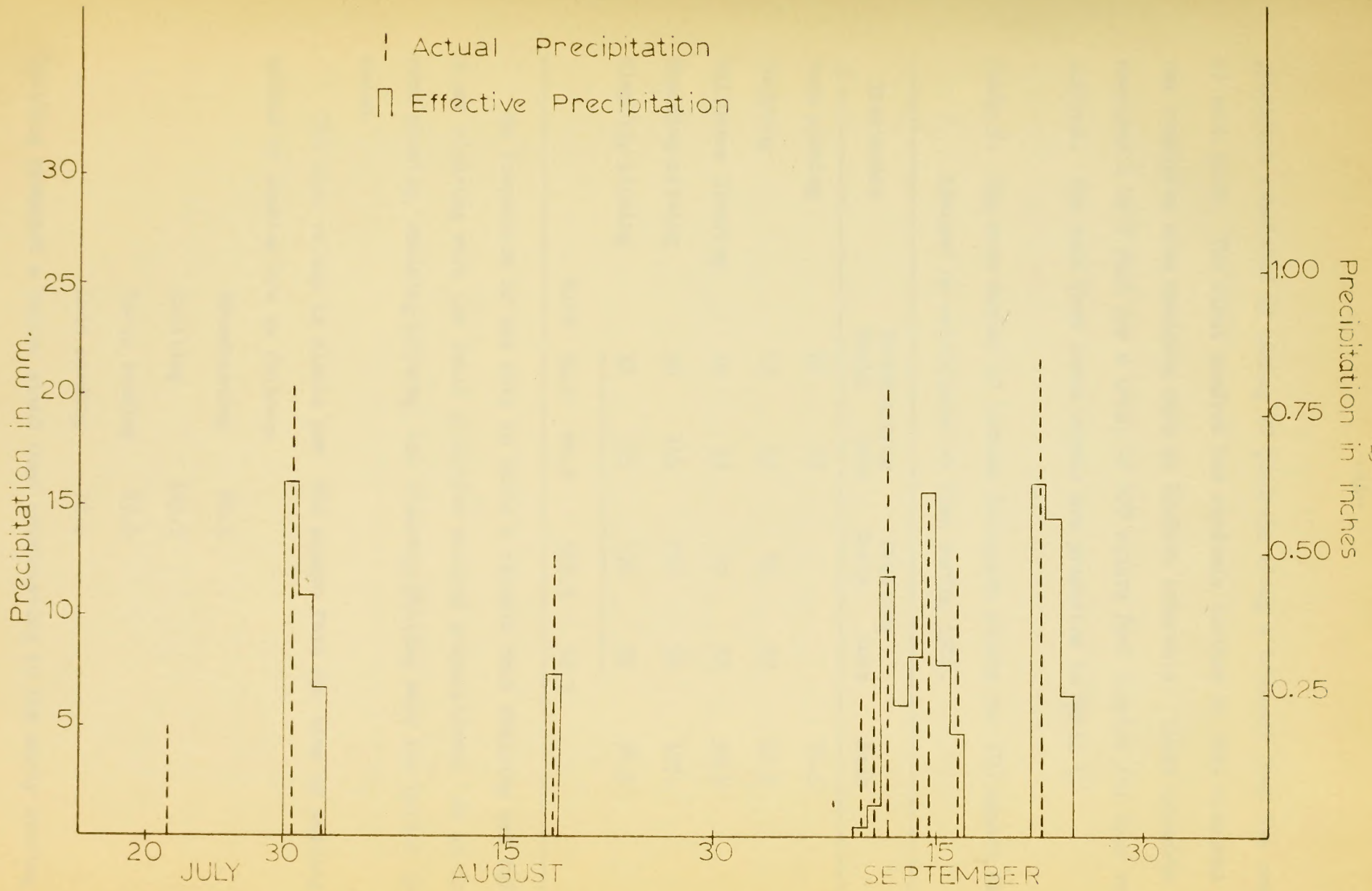


Figure 5. A comparison between actual and effective precipitation for plant growth during the summer of 1964 at Pima, Arizona.

procedure consisted of taking 10 quadrats along a transect down the center of each plot. The first quadrat was randomly located on this transect and the remaining nine quadrats were at 10-foot intervals. These quadrats measured 1 by 5 feet for a total of 200 square feet sampled for four replications. The data from these counts are presented in Table 5.

Table 5. The mean number of lehmann lovegrass plants per 200 square feet emerged or established at Pima during 1964.

Treatments	Broadcasting		Drilling		Mean
	Early	Late	Early	Late	
Root plowing	48	93			70.5
Chaining	23	49	88	29	47.2
Bulldozer Clearing	14	33	93	62	50.5
Chaining-pitting	34	144	278	52	127.
Clearing-pitting	32	134	136	92	98.5
MEAN	30.2	90.6	148.7	58.7	

An inspection of the data in Table 5 reveals that chaining and bulldozer clearing were the least effective seedbed preparations. As at Congress, root plowing, chaining-pitting, and clearing-pitting were the better treatments.

The mean values in plants per 200 square feet for time of seeding and method of seeding are as follows:

Broadcasting	60.4
Drilling	103.7
Early seeding	83.0
Late seeding	76.4

Drilling promoted a better stand than broadcasting in the early seeding in

March. In contrast to the Congress area, broadcasting in March was not as favorable as broadcasting in June.

The basis for a better plant response from the certain early seedings is not yet known. At both Pima and Congress, the best response from seeding early was from drilling. Broadcasting was more effective only at Congress during the early seeding. It is suspected that soil type might be a factor in explaining this difference. The soil at Congress is a light sandy loam and is subject to movement by wind. This movement facilitates seed coverage on the broadcast seedings. In contrast, the coarse soils at Pima are not as subject to wind movement and the early broadcast seedings may have suffered from a lack of coverage. Other factors besides seed coverage are also indicated because the early drilling produced a better stand than late drilling at both areas. Seed coverage was assumed to be adequate with drilling at both times and areas.

In addition to the studies on seedbeds and methods of seeding, a species adaptation nursery was established at Pima. The location of this nursery is as follows: Rows 1-17 of the nursery are located adjacent to and south of plot 19 of the 1964 Pima seeding study. Rows 18 and 19 are located approximately 40 feet south of plot 1 of the 1964 Pima seeding study. The seed rows run east and west. A numbered wooden stake was placed between the ends of the two rows of each species.

Seeding Procedure:

Two rows, 200 feet long and 1 foot apart were seeded with a rangeland drill on a March root-plowed seedbed. Seeding depth was $\frac{1}{2}$ to 1 inch. The species seeded and their corresponding row numbers are listed in Table 5.

Table 6. The species of range grasses seeded at Pima in June 1964.

Row Number	Species
1	Hairy grama (Bouteloua hirsuta)
2	Black grama (B. eriopoda)
3	Sideoats grama (B. curtipendula)
4	Blue grama (B. gracilis)
5	Vine mesquite (Panicum obtusum)
6	Halls panicgrass (P. hallii)
7	Pretoria panicgrass (P. coloratum)
8	Blue panicgrass (P. antidotale)
9	Creeping dropseed (Sporobolus usitatus)
10	Sand dropseed (S. cryptandrus)
11	Mesa dropseed (S. flexuosus)
12	Spike dropseed (S. contractus)
13	Boer lovegrass (Eragrostis chloromelas)
14	Wilman lovegrass (E. superba)
15	Plains lovegrass (E. intermedia)
16	Arizona cottontop (Trichachne californica)
17	Turkestan bluestem (Andropogon ischaemum)
18	Bush muhly (Muhlenbergia porteri)
19	Plains bristlegrass (Setaria macrostachya)

THE ARIZONA STRIP AREA

This phase of the progress report covers the data obtained from the Arizona Strip on the evaluations being made on seedbeds, methods of seeding, and species for seeding of sagebrush rangelands of Arizona. Although this project on seedbed evaluation was begun early in 1964, complementary studies have been in progress since 1962. To the extent that these earlier studies pertain to the current project, the data from them are also included with this report. Likewise, data from the 1964 plant counts on pelleted seed studies are appended herewith. Results and discussion are presented for the above studies and for supplemental studies as follows:

(1) Precipitation data

(2) Complementary seedbed studies

(3) The 1964 seeding studies

(4) Soil moisture content of various seedbeds

(5) Sagebrush control

(6) Species adaptation studies

(7) Fertilizer studies on seedling establishment

(8) Climatic and microclimatic measurements

(9) Evaluations on pest control

It is the purpose here to present a cumulative report on the evaluations of seedbeds, methods of seeding, and species studied on the Arizona Strip from 1962 through 1964.

Precipitation Data:

Approximately 80 percent of the precipitation for 1964 was received

during two periods. During March and April the precipitation was 2.98 inches and during July and August the precipitation was 3.72 inches. In contrast with the official weather station at Fredonia, 10 miles distant, the experimental area received a total of 8.41 inches while Fredonia received a total of 5.70 inches for 1964. A comparative rainfall record has been maintained since 1962 for Fredonia and the experimental area. This record is presented in Table 7.

Complementary Seedbed Studies:

Certain seedbeds have been under study since 1962. There are non-treated (check plots), brush chopped, brush chopped and pitted, and disk plowed. Two times of seeding were superimposed on these seedbeds and different species were seeded at each time. In general, blue grama and crested wheatgrass were seeded in the early summer (July) while crested wheatgrass and Russian wildrye were utilized in the early fall (September and October) seeding.

The 1962 Seeding: In 1962, two areas were seeded. One was called the primary area because it was typical of much of the sagebrush rangelands on the Arizona Strip. The other area was called the secondary area because it represented only a limited amount of sagebrush range. The secondary area had deep, alluvial soils, atypical of this rangeland. It was also believed to have a slightly higher rainfall which would increase the chance for a successful range seeding. The precipitation during the summer of 1962 was very scant. Therefore, no emergence from any of the seedings occurred until September 1962 at which time the emergence was poor. The emergence from this seeding improved with some seedlings from the fall seeding emerging in the spring of 1963. Fair emergence from both the summer and fall seeding had occurred by late summer in 1963 due to favorable precipitation. By

Table 7. Precipitation in inches for Fredonia, Arizona and the experimental reseeding area for 1961 through 1964.

Year and Station	Month of Year												
1961	J	F	M	A	M	J	J	A	S	O	N	D	Total
Experimental Area	-	-	-	-	-	-	-	-	-	-	1.07	.62	-
Fredonia	.44	.05	1.21	.34	.22	.00	.58	1.28	.12	.18	.86	.49	5.77
1962													
Experimental Area	.80	2.25	.80	.00	.05	.35	.10	.05	.70	.90	1.00	.50*	7.50*
Fredonia	.42	2.70*	.42	T	.26	.29	.11	.10	1.66	1.58	.59	.47	8.60*
1963													
Experimental Area	.50*	1.12	.30	.67	.02	.00	.22	2.28	.86	1.09	1.27	.00	8.33*
Fredonia	.58	1.16	.35	.47	T	.22	T	2.79	2.11	1.23	1.46	T	10.37
1964													
Experimental Area	T	.00	1.31	1.67	.39	.28	2.02	1.70	.15	.00	.14	.75	8.41
Fredonia	.14	T	.92	1.38	.69	.03	.44	.66	.35	.32	.35	.42	5.70

* - Amount is wholly or partially estimated

T - Trace

Table 1. Precipitation in Inches for Fredonia, Arkansas and the surrounding region for the 10th through 19th.

Year and Station	Month of Year												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
1981													
Experimental Area	.44	.05	.71	.58	1.38	-	-	-	-	.72	.88	1.01	5.77
Fredonia	.44	.05	.71	.58	1.38	-	-	-	-	.72	.88	1.01	5.77
1982													
Experimental Area	.88	.52	.80	.00	.25	.00	.05	.70	.88	.50	1.58	1.00	6.86*
Fredonia	.56	.52	.80	.00	.25	.00	.05	.70	.88	.50	1.58	1.00	6.86*
1983													
Experimental Area	.50*	.52	.80	.00	.25	.00	.05	.70	.88	.50	1.58	1.00	8.33*
Fredonia	.50*	.52	.80	.00	.25	.00	.05	.70	.88	.50	1.58	1.00	8.33*

* - Amount is short of Actual as Rain Gauge overflowed

- - None

1964, this 1962 seeding had become well established and plant counts were made in 1964. These data are presented in Tables 8 and 9 for both the primary and secondary areas.

From these data in the above tables and from observations made since 1962, certain trends are evident. They are as follows:

(1) Well-prepared seedbeds effected the better establishment of seeded grasses. Only an occasional grass plant, native or seeded, can be found on the non-treated seedbeds on which sagebrush was not controlled.

(2) On the prepared seedbeds having adequate sagebrush control, native grasses have increased in number. In particular, bottlebrush squirreltail, spike dropseed, and sand dropseed have increased on the primary area while Indian ricegrass and western wheatgrass have increased on the secondary area. This increase in indicative of the competitive nature of sagebrush.

(3) Of the summer-seeded species, crested wheatgrass performed better than blue grama, both in density of plants per acre and in volume of forage. From this 1962 seeding, crested wheatgrass produced a better stand from the July seeding than the fall (October) seeding.

(4) A characteristic feature of Russian Wildrye (fall seeded) is its slow establishment. Although a fair stand has now been established, this stand is not as good as the crested wheatgrass stand from the summer seeding.

The 1963 Seeding: This seeding followed the same experimental procedures used in 1962, excepting that crested wheatgrass was not used in the summer seeding, and only the primary area was seeded. One additional seeding variable was included for study and this consisted of seeding into standing

Table 8. The average number of plants per 100 square feet on various seedbeds seeded in July at two areas near Fredonia in 1962. The plant counts were made in 1964.

Method of Seeding and Seedbed Preparation	Average No. of Plants per 100 Square Feet	
	Primary Area	Secondary Area
Drilled Plots		
Crested wheatgrass		
Seedbed: Chopped	22.75	49.75
Chopped-pitted	17.75	75.25
Wheatland plowed	13.50	68.25
Blue Grama		
Seedbed: Chopped	2.75	99.75*
Chopped-pitted	1.50	30.00*
Wheatland plowed	2.00	15.25*
Airseeded Plots:		
Crested Wheatgrass		
Seedbed: Non-treated	0.00	4.75
Chopped	35.75	273.50
Chopped-pitted	5.25	220.75
Wheatland plowed	6.50	194.25
Blue Grama		
Seedbed: Non-treated	0.00	29.50*
Chopped	2.50	15.50*
Chopped-pitted	1.25	18.75*
Wheatland plowed	0.00	8.25*

* Native blue grama included in counts - unable to distinguish from seeded plants.

Table 9. The average number of plants per 100 square feet seeded in October, 1962 on various seedbeds at two areas near Fredonia. The plants were counted in 1964.

Method of Seeding and Seedbed Preparation	Average No. of Plants per 100 Square Feet	
	Primary Area	Secondary Area
Drilled Plots		
Crested Wheatgrass		
Seedbed: Chopped	26.33	46.25
Chopped-pitted	43.33	44.75
Wheatland plowed	30.00	72.25
Russian wildrye		
Seedbed: Chopped	36.33	18.75
Chopped-pitted	36.67	24.75
Wheatland plowed	22.33	27.50
Airseeded Plots		
Crested Wheatgrass		
Seedbed: Non-treated	0.00	0.25
Chopped	13.33	88.75
Chopped-pitted	39.00	143.00
Wheatland plowed	87.50	78.00
Russian Wildrye		
Seedbed: Non-treated	0.00	0.00
Chopped	15.67	0.50
Chopped-pitted	9.33	2.50
Wheatland plowed	0.50	10.75

sagebrush previously sprayed with 2,4-D.

The amount and distribution of rain during 1963 was very favorable for the germination and emergence of the seeded grasses from both summer and fall seedings. The data and procedures pertinent to the 1963 seeding have been covered extensively in the 1963 annual progress report. The plant counts made in 1964 on the 1963 seeding are given in Tables 10, 11 and 12. These plant counts are presented for three dates of counting, and it can be noted that, in general, the number of plants was less at the June and July dates of counting. This reduction in stand during this time may be due to loss of seedlings from early summer drought. It does point out the variation in stand that can be obtained at different dates of counting. The average number of plants from several dates of counting were analysed statistically and these data are presented in Table 13. It was found that there was no significant difference due to counting at different dates. However, for purposes of discussion in this report, the latest plant count in the season will be utilized. It is assumed that this count represents those plants more completely established.

The data from the 1964 plant counts of the 1963 seeding indicate:

(1) The best stands of seeded grasses were produced on the better prepared seedbeds which are those seedbeds having a satisfactory control of sagebrush. There was no significant difference in stands on those seedbeds where 60 to 80% control of sagebrush was obtained. This is illustrated in Table 14 wherein the plowed, chopped, and chopped-pitted seedbeds are of the same degree of effectiveness. The seedbed on which the sagebrush was controlled by herbicidal applications of 2,4-D was not significantly better than the check plot. However, subsequent observations have shown that the herbicide

Table 10. The average number of plants of blue grama per 100 square feet on various seedbeds seeded in July 1963 at Fredonia.

Method of Seeding and Seedbed Preparation	Date of Plant Count		
	9/8/63	6/10/64	8/25/64
Drilled			
Seedbed:			
Non-treated	67.50	58.25	41.25
Herbicide sprayed	143.50	111.25	89.25
Chopped	352.25	281.75	252.25
Chopped-pitted	298.00	192.25	183.75
Disk-plowed	303.00	204.75	189.75
Airseeded			
Seedbed:			
Non-treated	0.00	0.00	0.75
Herbicide sprayed	0.00	1.25	2.50
Chopped	15.25	32.75	47.00
Chopped-pitted	2.75	9.25	15.75
Disk-plowed	3.50	14.00	13.75

Table 11. The average numberof plants of crested wheatgrass per 100 square feet on various seedbeds seeded in September 1963 at Fredonia.

Method of Seeding and Seedbed Preparation	Date of Plant Count		
	6/10/64	7/30/64	8/25/64
Drilled			
Seedbed:			
Non-treated	243.25	105.75	116.75
Herbicide sprayed	252.25	158.75	188.75
Chopped	369.25	271.75	274.75
Chopped-pitted	388.75	285.75	284.25
Disked	352.00	276.50	272.25
Airseeded			
Seedbed:			
Non-treated	8.75	3.25	8.00
Herbicide sprayed	8.25	0.25	4.50
Chopped	100.25	74.75	86.00
Chopped-pitted	79.25	51.00	64.00
Disked	79.75	48.00	56.00

Table 12. The average number of plants per 100 square feet on various seedbeds sown with Russian wildrye in September, 1963 at Fredonia.

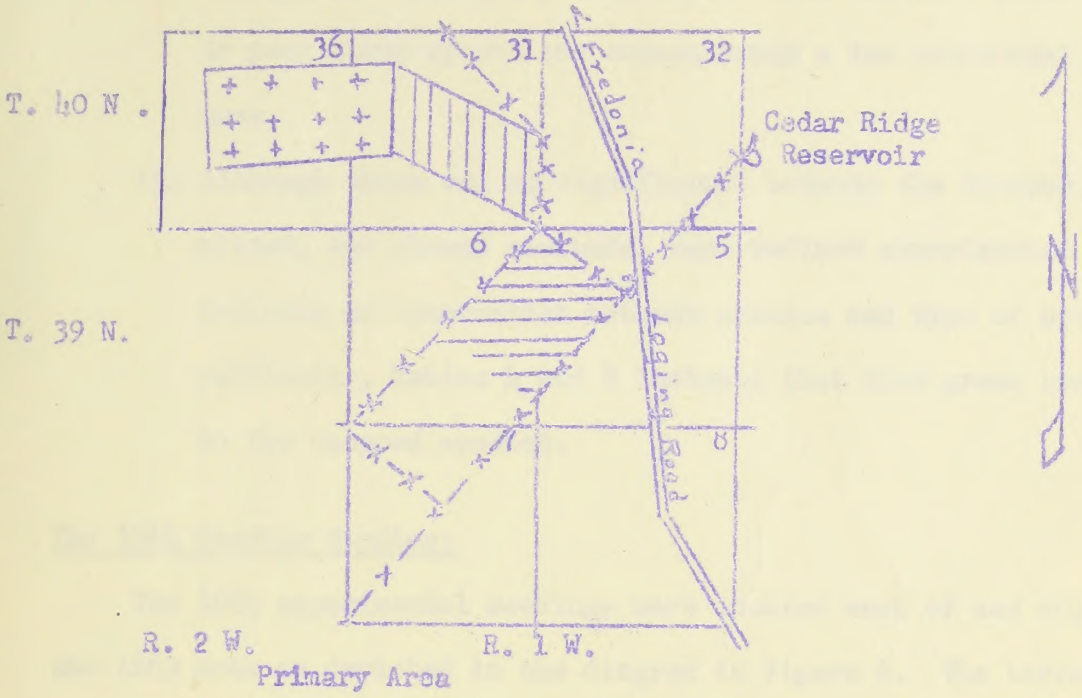
Method of Seeding and Seedbed Preparation	Date of Plant Count		
	6/10/64	7/30/64	8/25/64
Drilled			
Seedbed:			
Non-treated	88.75	8.25	34.00
Herbicide sprayed	138.50	68.25	86.50
Chopped	221.75	151.50	170.75
Chopped-pitted	366.00	181.25	152.50
Disked	216.50	160.75	171.00
Airseeded			
Seedbed:			
Non-treated	0.75	0.00	0.00
Herbicide sprayed	0.50	0.00	0.50
Chopped	8.75	7.50	14.75
Chopped-pitted	50.00	30.00	43.75
Disked	21.25	9.50	19.50

Table 13. The average number of plants at each counting date of three species seeded in 1963. All figures underscored by the same line in each row indicate no significant difference when tested at the 5 percent level.

Species	1963	Date at Time Counts Were Made		1964		
	Aug. 23	Sept. 1	Sept. 8	June 7	July 29	Aug. 27
	(Average number of seedlings per square foot)					
Blue Grama	.46	.51	.61	.47	.40	.43
Crested wheatgrass	(Not seeded)			.97	.67	.72
Russian wildrye	(Not seeded)			.54	.32	.36

Table 14. The average number of plants of three species seeded on five seedbeds in 1963. All figures underscored by the same line in each row indicate no significant difference when tested at the 5 percent level. The data were taken in 1964.

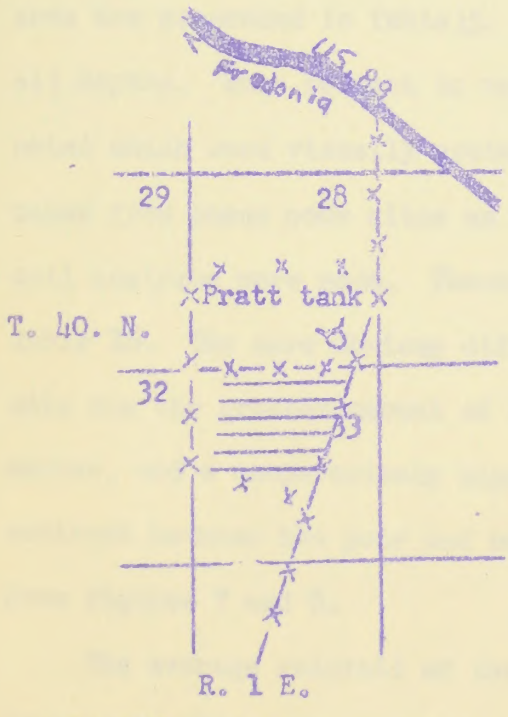
Species	Seedbed Treatment				
	Non-treated	Herbicide	Plowed	Chopped	Chopped-pitted
	(Average number of seedings per square foot)				
Blue grama	.13	.26	.63	.81	.57
Crested wheatgrass	.42	.54	1.01	.94	1.03
Russian wildrye	.11	.25	.65	.52	.51



ARIZONA STRIP

Range Reseeding Sites

Bureau of Land Management Range Units



LEGEND

— X — Existing fences

1962 reseeding sites

1963 reseeding site

1964 reseeding site

Scale: 1": 1 mile

Figure 6. Primary and secondary areas for reseeding on the Arizona Strip

was applied during a period of low soil moisture which resulted in poor shrub growth and consequently a low herbicidal effectiveness.

(2) Although there was no significance between the chopped, chopped-pitted, and plowed seedbeds, more refined experimental methods may indicate an interaction between species and type of seedbed. In particular, Tables 4 and 8 indicate that blue grama responded best to the chopped seedbed.

The 1964 Seeding Studies:

The 1964 experimental seedings were located west of and adjacent to the 1963 area as depicted in the diagram in Figure 6. The terrain was gently rolling with slopes up to 6 percent. The soil on the area was shallow and rock outcrops were numerous. Soil analyses were made on soil samples taken from this area. The characteristics of the soil of the general area are presented in Table 15. This soil classifies as a loam throughout all depths. With respect to vegetative growth, small occasional areas were noted which were visually estimated to be poor sites. Soil samples were taken from these poor sites as well as the better sites and comparative soil analyese were made. These comparative analyses are presented in Table 16. The more obvious difference in this comparison is the better site has the greater amount of soluble salts, a higher percentage of organic matter, and a comparatively high level of nitrates and phosphates. The contrast between the poor and better sites can be more readily visualized from Figures 7 and 8.

The average rainfall of the area is estimated to be between 9 and 10 inches annually. The rainfall pattern of the past 3 years was previously presented in Table 7. Big sagebrush dominates the native vegetation, and

Table 15. A composite soil analysis of the 1964 experimental reseeding area near Fredonia.

Soil Depth in Inches	Sand	Silt	Clay	pH	Soluable Salts EC x 10^3	Soluable Salts ppm	O.M. %	NO_3 ppm	PO_4 ppm	EDTA ml
	----percent----									
1 to 3	47.7	39.7	12.5	8.0	.37	260	1.20	19.0	8.0	0.38
3 to 6	41	41.7	17.2	7.9	.28	197	1.31	13.0	3.0	0.30
6 to 12	40	40	19	7.9	.31	219	1.45	13.0	2.0	0.33

Table 16. Soil analysis of two adjacent sites on the 1964 experimental reseeding area near Fredonia.

Soil Depth in Inches	Sand	Silt	Clay	pH	Soluable Salts EC x 10^3	Soluable Salts ppm	O.M %	NO_3 ppm	PO_4 ppm	EDTA ml
	----percent----									
1 to 3										
Poor site	41	44	13	8.0	.32	221	1.40	11.0	6.0	.33
Better site	43	47	10	7.7	.93	659	6.65	16.0	12.	1.14
3 to 6										
Poor site	41	43	16	7.9	.38	268	1.58	6.6	2.3	.39
Better site	42	45	13	7.9	.50	350	3.07	18.0	4.0	.59
6 to 12										
Poor site	41	43	16	7.8	.43	304	1.18	6.0	2.5	.34
Better site	38	44	17	7.8	.56	395	2.42	12.0	2.0	.60

Figure 7. The contrast of a small area where vegetative growth is poor in comparison with surrounding vegetation near Fredonia, Arizona.

Figure 8. Characteristic vegetative and root growth on a "poor" site on sagebrush rangelands near Fredonia.

it accounts for over 90% of the total composition of the plant community. The average coverage of big sage in this area is slightly over 20 percent.

The experimental variables under study in 1964 were as follows:

(1) Four seedbeds consisting of brush chopped, chopped and pitted, tandom disc plowed, and burned. In addition, preliminary studies were made on one seedbed having received an application of the herbicide 2,4-D.

(2) Two seeding methods: broadcasting and drilling.

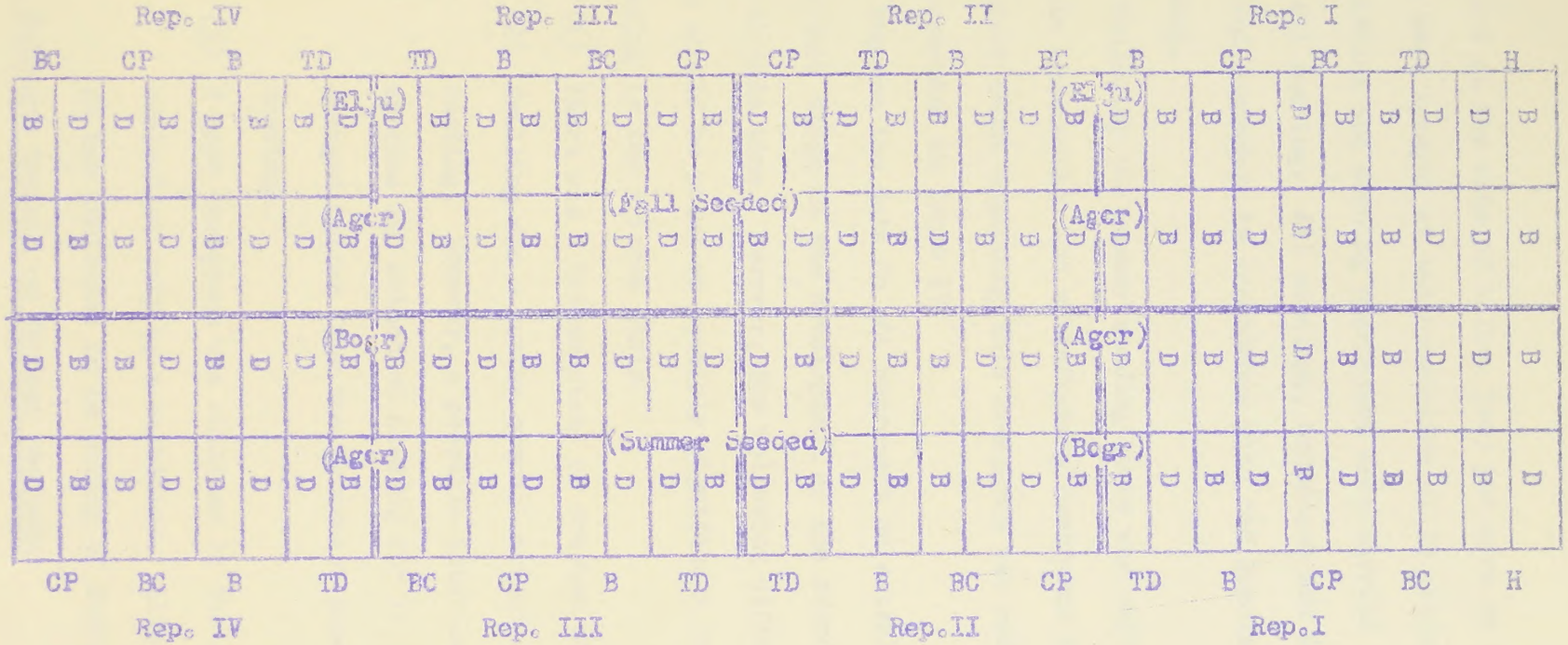
(3) Two seasons of seeding: early summer and early fall.

(4) Three species were used to test the effectiveness of the various seedbeds and seasons of seeding. Blue grama and crested wheatgrass were summer seeded and crested wheatgrass and Russian wildrye were fall seeded.

All experimental variables or treatments were replicated four times excepting the herbicide sprayed seedbed. Each seedbed was about three acres in size. Superimposed on the seedbeds were the other seeding variables having a plot size of about 3/4 acre.

The experimental program in 1964 for the evaluation of seedbeds, methods of seeding, and time of seeding with various species is diagrammed in Figure ?. Other supplemental studies were conducted during 1964 on species adaptation, herbicidal control of sagebrush, comparative soil moisture levels on various seedbeds, and the effects of fertilizer in promoting seedling establishment. These studies will be discussed later in this report under their respective headings.

The plowing and brush chopping operations were conducted in late June and early July. The herbicide treated seedbed was sprayed with the butyl ester



Seeding legend
B = Broadcast
D = Drilled
Agcr = Crested Wheatgrass
Bogr = Blue Grama
Elju = Russian Wildrye

Seedbed legend
H = Herbicide
B = Burned
BC = Brush chopped
CP = Brush chopped plus pitted
TP = Tandem Disked

Fig. 9. Revised diagram of seedbed preparation and seeding treatments on the Arizona Strip Seeding Project, 1964.

of 2,4-D at the rate of 4 lbs. (ae) per acre on April 20. A total of five acres were sprayed at the proportion of 10 gallons of solution per acre. The pitting and burning operations were carried out later in the season for the fall seeding. All seedings, broadcast and drilled, were completed in July and September in accordance with the species planted and season of planting.

Following the summer seeding there was sufficient precipitation to promote germination and satisfactory emergence from nearly every plot. One plant count depicting this emergence was made on August 26. These data are presented in Table 17.

Because the data do not represent an established stand but rather a transitory stage in the development of the stand, no conclusion should be made at this time. However, the following differences between the various means should be noted as possible significant factors affecting range reseeding in the Arizona Strip.

(1) There was a better stand of crested wheatgrass than blue grama.

(2) Drilling was a better overall method of seeding than was broadcasting. However, a possible inter-action might exist between species and method of seeding for it is noted that blue grama emerged better from the broadcast seeding in contrast to drill seeding.

(3) A good emergence was obtained on the seedbed where the brush was controlled only by a herbicide. Although only a preliminary study, it has indicated to be worthy of future study.

Soil Moisture Content on Various Seedbeds:

A comparison was made of the soil moisture levels of the various seedbeds prepared in 1963 and 1964. Soil samples were taken from depths of 1,

Table 11. The average number of plants per 100 square feet from drilling and broadcasting various species on different seedbeds at Fredonia. Seedings were made July, 1964 and plant counts were taken August 26, 1964.

Seedbed Preparation	Method of Seeding and Species Seeded				
	Crested Wheatgrass		Blue Grama		
	Drilled	Broadcast	Drilled	Broadcast	Mean
Herbicide sprayed*	722.0	11.0	307.0	232.0	318.0
Brush chopped	809.5	90.5	102.2	253.2	313.8
Chopped & pitted	631.5	101.5	79.2	198.0	252.5
Disk-plowed	444.7	70.0	50.5	181.5	186.6
Burned	357.0	80.0	49.2	187.2	168.3
MEAN	592.9	70.6	117.6	210.4	

Species Means: Blue Grama 164.0

Crested wheatgrass 331.7

Method of Seeding Means:

Drilling 355.2

Broadcasting 140.5

* Herbicide Treated Seedbed not replicated -
All other values are means of four replications

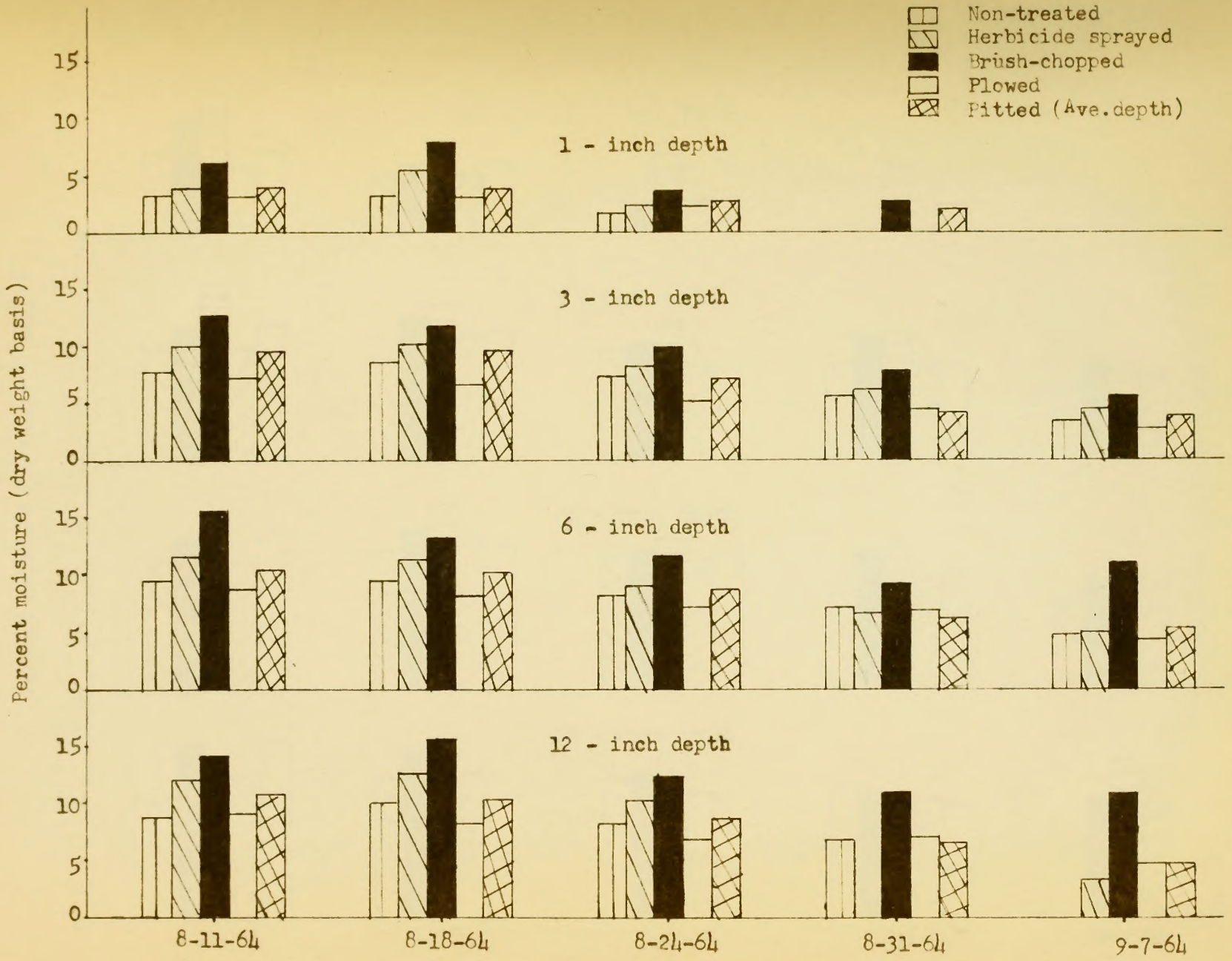


Figure 10 Percentage soil moisture at four depths on five seedbeds prepared in 1963 on sagebrush rangeland.

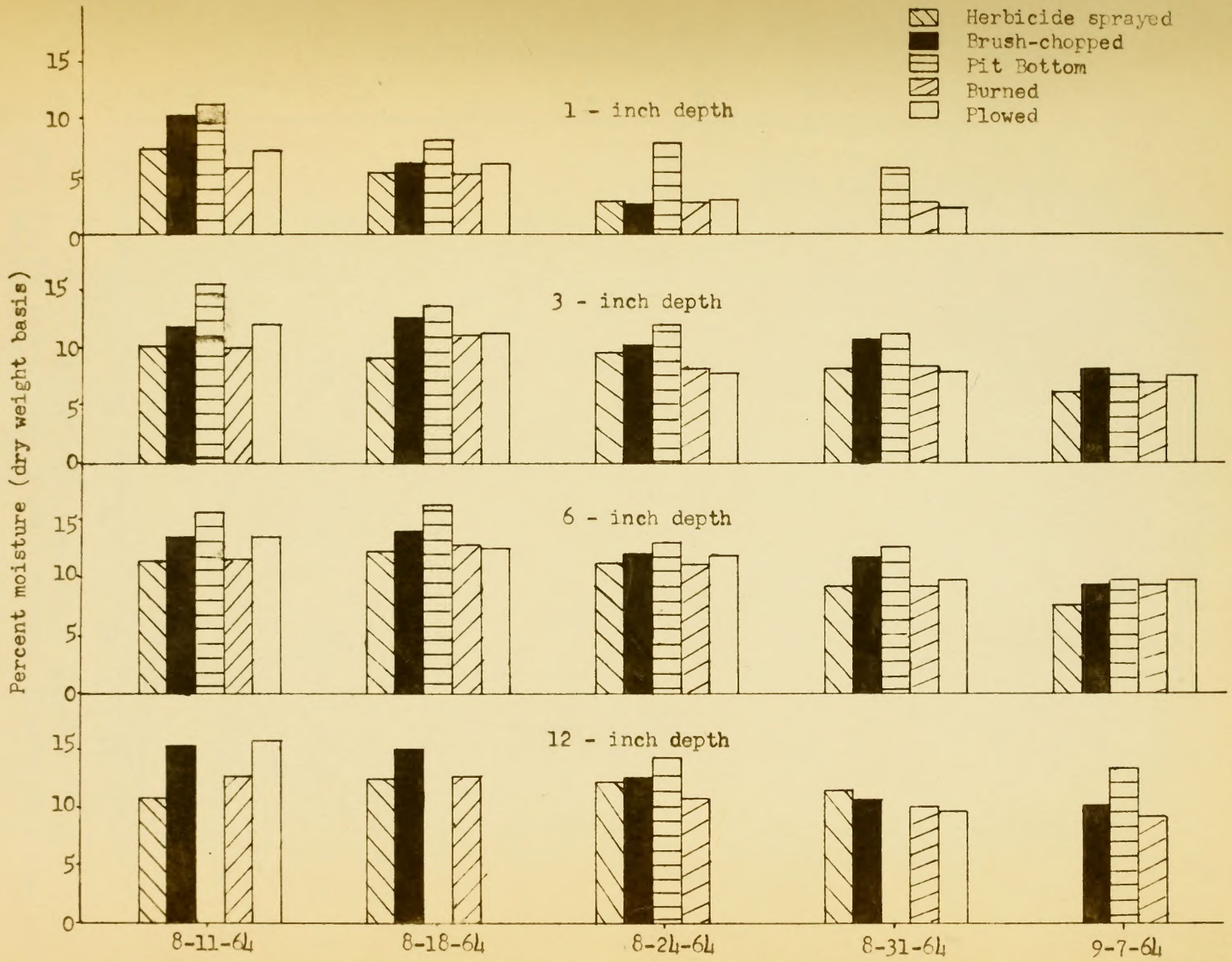


Figure 11. Percentage soil moisture at four depths on five seedbeds prepared in July 1964 on sagebrush rangeland.

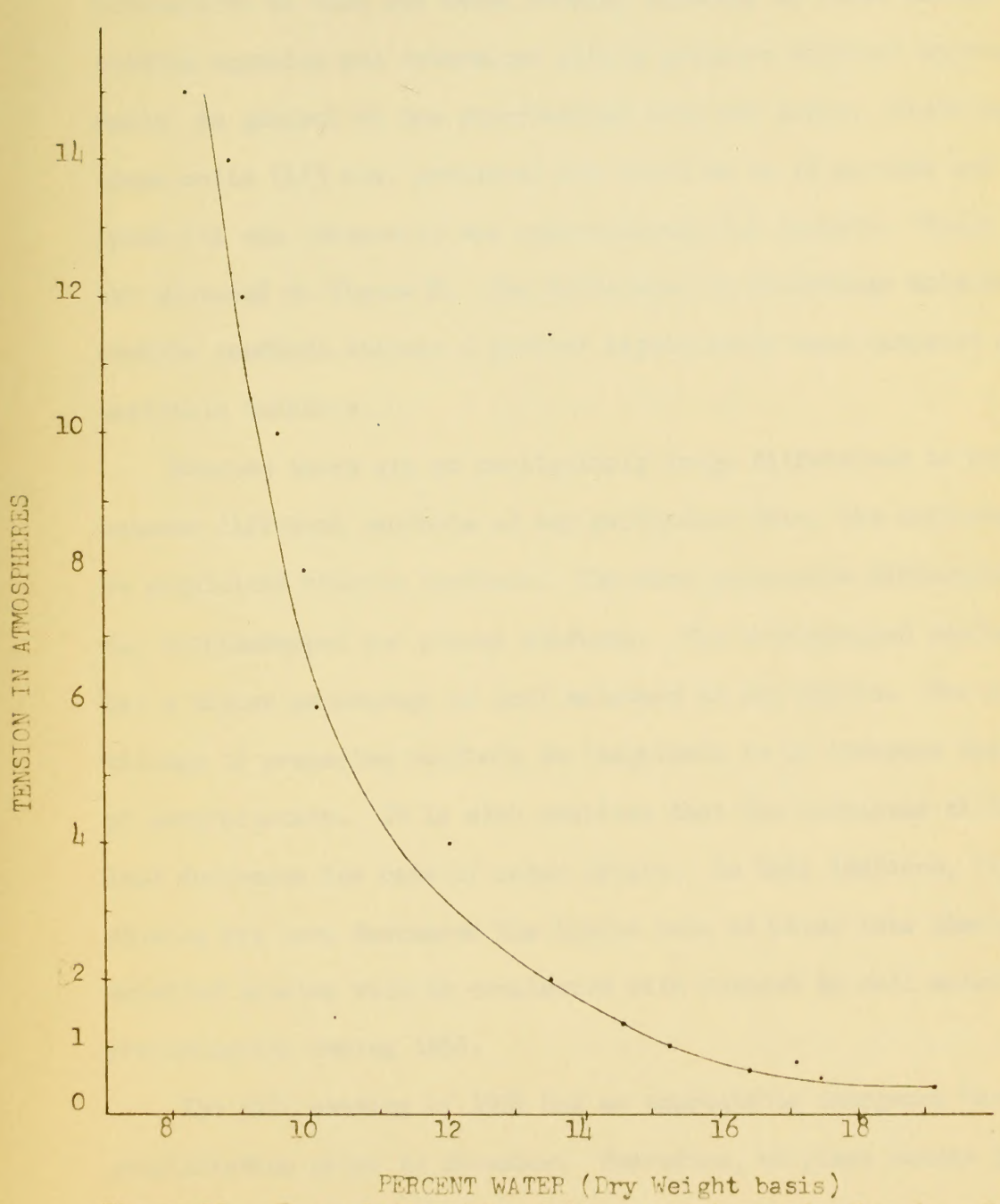


Figure 12. The relationship of the percentage of water in a loam soil to its tension in atmospheres.

3, 6, and 12 inches, and the percentage soil moisture (dry wt. basis) was determined by standard gravimetric procedures. The data from these determinations are illustrated in Figures 10 and 11.

Before preliminary interpretations are made from these data, it is informative to view the water holding capacity of these soils. The water holding capacity was determined with a pressure membrane apparatus. The soils in general on the experimental area are loams. Field capacity for these soils (1/3 atm. pressure) was found to be 19 percent and the wilting point (15 atm. pressure) was approximately 8.5 percent. These relationships are depicted in Figure 12. The difference in percentage moisture of the various seedbeds assumes a greater significance when compared with the available moisture.

Whereas there are no particularly large differences in moisture levels between different seedbeds at any particular date, the differences tend to be consistent between seedbeds. The most noticeable difference is between the branchchopped and plowed seedbeds. The brushchopped seedbed generally has a higher percentage of soil moisture at all depths. One purpose of tillage in preparing seedbeds on rangelands is to increase the penetration of precipitation. It is also realized that the continued tillage of cropland decreases the rate of water intake. In this instance, it appears that plowing may have decreased the intake rate of water into these soils. More detailed studies will be considered with respect to soil moisture and effective precipitation during 1965.

The fall seeding of 1964 had no appreciable emergence because of limited precipitation prior to December. Therefore, no plant counts from this seeding were available for this report.

Sagebrush Control

In the previous section on seedbeds, the control of sagebrush was discussed to a limited extent with respect to its removal as a competitive factor. Although a certain degree of shrub control is achieved in the mechanical preparation of seedbeds, the objective of preceding discussion was to present results in terms of plant establishment. In contrast, the objective of the following discussion is to present results and discussion of only sagebrush control.

Each seedbed prepared in 1962 and 1963 was sampled in 1964 with reference to the number of living sagebrush plants. These samples consisted of counting the plants in eight 100 square-foot circular plots on each replication of each seedbed. A percentage control was then calculated based on the number of living sagebrush plants in the appropriate non-treated plots. These data, presented in Table 12, show a range in percent control from 60 to 80 percent. In general, brushchopping gave the least control while plowing gave the best control.

The pitting operation is not particularly effective as a brush control measure; however, its effects are additive on those areas previously brushchopped. The herbicide treatment in 1963 consisted of spraying with 4 lbs per acre (ae) of the butyl ester of 2,4-D. The poor control with this treatment was due to spraying during a period of low soil moisture. It has been observed that sagebrush is becoming reestablished on certain plots. This is believed to be fostered by favorable climatic conditions and the absence of competitive grass.

In view of the apparent critical requirement for adequate soil moisture while applying herbicides, a time of herbicide application study was conducted in 1964. The factors included in this study were:

Table 18. Evaluation of sagebrush control on various seedbed preparations on the Arizona Strip. The data was taken June 1964.

Area and Seedbed	Ave. No. of Plants Per 1000 sq. ft.	Percent Control
1962 Primary Area		
Non-treated	137.32	
Brush Chopped	54.82	60.08
Chopped-pitted	29.02	78.13
Plowed (Wheatland Plow)	41.86	69.52
1962 Secondary Area		
Non-Treated	152.19	
Brush Chopped	32.26	78.81
Chopped-pitted	24.61	83.83
Plowed (Wheatland Plow)	30.86	79.62
1963 Area		
Non-treated	149.68	
Herbicide (sprayed)	144.27	3.63
Brush Chopped	58.64	60.83
Chopped-pitted	35.31	76.41
Plowed (Tandom Disked)	16.77	88.80

(1) Five herbicides: 2,4-D, 2,4,5-T, Banvel-D, a mixture (1:1) of 2,4-D and 2,4,5-T (2D-2T), and Tordon.

(2) Three rates: 1, 2, and 4 lbs. (ae) per acre except for Tordon which was 1/2, 1 and 2 lbs. per acre.

(3) Four dates of spraying: March 28, April 20, May 8, and June 4.

(4) Three replications of the above factors set-up as a complete randomized block.

Each plot was 20 by 75 feet in size. Between the plots there was a 10-foot buffer zone. The herbicide applications were made from a 20-foot spray boom mounted on the rear of a pick-up. The spray mixture was applied at the rate of 10 gallons per acre at 40 p.s.i. pressure. At each date of application, soil samples and stem-tips were collected for subsequent moisture determinations. These treatments were evaluated in November 1964 and the results are presented in Table 19.

It can be noted that the percentage moisture in the stem tips does not correlate well with the degree of control during 1964 (Table 20). Whereas the percentage moisture at the earliest date of application and best control was 53.7%, it was 62% at the latest date of application and the poorest control. In other words, a high moisture content of the leaves did not indicate the proper time of spraying. It is suspected that such a correlation might exist if no new growth had occurred; and thus, the percentage moisture would represent more nearly the hydration or dehydration of the tissues. When new growth occurs, it may not represent additional hydration but instead a comparative decrease in dry matter at a constant level. It is suggested that the one-pound rate of all herbicides be omitted in future studies because of its non-effectiveness in the 1964 studies.

Table 19. An evaluation of sagebrush control by various herbicides applied in 1964. The values are qualitative ratings.*

Herbicide and Rate Per Acre		Date of Application 3-28-64	4-20-64	5-8-64	6-4-64
2,4-D	1 lb	0.6	1.3	1.3	0.3
	2 lb	2.3	2.6	2.3	1.0
	4 lb	4.0	3.6	4.0	2.0
2,4,5-T	1 lb	2.6	2.0	1.3	0.6
	2 lb	4.0	3.6	4.0	1.6
	4 lb	4.3	4.0	3.6	1.6
Banvel-D	1 lb	2.6	0.6	1.0	0.0
	2 lb	4.6	1.0	1.3	0.6
	4 lb	5.0	2.6	3.3	1.6
2D-2T	1 lb	0.3	0.6	0.3	0.0
	2 lb	2.0	0.6	1.3	1.3
	4 lb	2.6	2.3	2.3	1.0
	MEAN	2.9	2.0	2.2	.9
Tordon	½ lb	0.0	-	-	-
	1 lb	0.0	-	-	-
	2 lb	2.0	-	-	-

*Ratings based on percent defoliation; average of three replications.

5.0 Excellent
4.0 Good (less than 3.5 considered unsatisfactory)
3.0 Fair
2.0 Poor
1.0 No seedhead production-some defoliation
0.0 No noticeable effect

Table 20. Average percent soil moisture and sagebrush stem-tip moisture during the 1963 and 1964 herbicide spraying dates on the Arizona Strip.

Depth of Soil Sample***	Dates of Herbicide Application 1963			1964			
	4-17	5-12	6-7	3-28	4-20	5-8	6-4
1 inch	3.83*	2.88	2.12	15.67	10.75	13.72	2.12
3 inch	9.53	7.20	3.43	18.45	14.59	15.87	4.00
6 inch	11.11	10.00	4.56	20.08	17.40	16.23	7.64
12 inch	10.36	10.83	6.80	22.12	19.25	17.41	10.10
Sagebrush Tips*** (Fresh wt. basis)	135.38* (57.5)	101.52 (50.3)	74.83 (42.8)	116.45 (53.7)	186.98 (65.1)	175.79 (63.7)	163.64 (62.0)
New growth in inches				0	0.75	2.5	4.+
Estimated average percent control, all herbicides.				58%	40%	44%	18%

* All percent moisture data on a dry weight basis.

** Oven dried at 100° C for 48 hours.

*** Oven dried at 70°C for 48 hours.

It does appear that the soil moisture level is correlated with the degree of control. If a limitation was to be suggested with regard to the time of herbicide application in the Arizona Strip, it might be to spray only when the soil moisture at the 3-inch depth is above 12 percent. Satisfactory control of sagebrush was obtained with 2,4-D (4 lb/acre, ae) when applied at the earlier dates, presumably because of adequate soil moisture. The herbicide 2,4,5-T appeared to be more effective than 2,4-D at the earlier dates of application and was effective at lower rates. This may indicate that 2,4,5-T is physiologically more active under lower temperatures than 2,4-D. Only at the earliest date of application did Banvel-D effect adequate control of sagebrush. Tordon was considered to be comparatively non-effective.

Species Observation Trials:

Eighteen to twenty-five species were sown in both summer and fall seasons in 1962, 1963 and 1964. These species are being evaluated with respect to their adaptation to the environmental conditions of the Arizona Strip. These species were drilled into plots measuring about 20 feet wide by 300 feet long. Each plot had two seedbed preparations - plowed and brush-chopped. The depth of seeding was about one inch for all species. Most of these plots have been fenced to exclude rabbits.

The data from these species consist of plant counts made periodically on all species observation plots during the summer months. These counts consisted of the total number of plants in twenty 1 by 5-foot quadrats. The species planted and their density are presented in Tables 21, 22, and 23. The results from these data and supporting observations are presented by years of seeding.

Table 21. The number of plants per 100 square feet on the species observation plots planted on July 16, 1962 and October 12, 1962 at Fredonia.

Plot No.	Species	Common Name	8/27/63	8/21/64
1	Bocu	Sideoats grama	8.	9.
2	Boer	Black grama	10.	8.
3	Bogr	Blue grama	9.	4.
4	Atca	Four-wing saltbush	2.	5.
5	Orhy	Indian ricegrass	11.	6.
6	Sema	Plains bristlegrass	4.	9.
7	Muwr	Spike muhly	97.	12.
8	Anis	Turkestan bluestem	0.	0.
9	Erbi	Bicolor lovegrass	18.	1.
10	Erle (3506)	Lehmann lovegrass	2.	1.
11	Erle (A68)	Lehmann lovegrass	327.	1.
12	Ercu	Weeping lovegrass	24.	0.
13	Erch	Boer lovegrass	156.	0.
14	Spai	Alkali sacaton	25.	29.
15	Spus	Creeping dropseed	51.	8.
16	Sper	Sand dropseed	98.	44.
17	Spco	Spike droseed	617.	136.
18	Agcr	Crested wheatgrass	34.	25.
		(Fall Seeded - October 12, 1962)		
1	Agcr	Crested wheatgrass	17.	43.
2	Elju	Russian wildrye (Colo.)	30.	44.
3	Elju	Russian wildrye (Utah)	7.	22.
4	Agcr.	Crested wheatgrass (N. Dakota)	13.	28.
5	Agin	Intermediate wheatgrass	37.	44.
6	Agsm	W (Utah)		
6	Agsm	Western wheatgrass	5.	23.
7	Agin	Intermediate wheatgrass (Amur)	15.	18.
8	Agtr	Pubescent wheatgrass	35.	48.
9	Elci	Giant wildrye	2.	2.
10	Agsi	Siberian wheatgrass	33.	96.
11	Elsa	Salina wildrye	6.	6.
12	Sami	Burnet	5.	0.
13	Atca	Four-wing saltbush	0.	2.
14	Orhy	Indian ricegrass	10.	12.
15	Eula	Winterfat	0.	0.
16	Orhy	Indian ricegrass (Wyo.)	0.	0.
17	Orhy	Indian ricegrass (Wyo.-Tucson)	1.	0.
18	Orhy	Indian ricegrass (Wyo. Red desert)	2.	1.
19	Sihy	Squirreltail (Springerville)	11.	11.

Table 22. The number of plants per 100 square feet in the 1963 Species Observation Plots. These species were sown July 15 and September 9 at Fredonia [illegible].

Plot No.	Species	Common Name	Date Counted 8/22/63	6/6/64	8/20/64
1	Bogr	Blue grama	972.	337.	273.
2	Bocu	Sideoats grama	446.	398.	253.
3	Boer	Black grama	392.	241.	184.
4	Sami	Burnet	14.	15.	1.
5	Atca	Four-wing saltbush	11.	19.	18.
6	Sema	Plains bristlegrass	14.	18.	17.
7	Orhy (3763)	Indian ricegrass	6.	23.	33.
8	Orhy (4406)	Indian ricegrass	16.	64.	118.
9	Orco	Blue ricegrass	43.	31.	27.
10	Stor	Mandan ricegrass	1.	8.	11.
11	Ledu	Green sprangletop	641.	2.	1.
12	Muwr	Spike muhly	456.	391.	160.
13	Tedr	Karoo grass	299.	130.	62.
14	Dier	Bunch wolly fingergrass	141.	0.	0.
15	Spcr	Sand dropseed	823.	849.	462.
16	Spco	Spike dropseed	202.	123.	57.
17	Spus	Creeping dropseed	438.	141.	115.
18	Spai	Alkali sacaton	238.	119.	111.
19	Erle (A68)	Lehmann lovegrass	1102.	0.	0.
20	Erle (A-14107-08)	Lehmann lovegrass	1806.	1.	29.
21	Erle (A-14328)	Lehmann lovegrass	957.	4.	1.
22	Erbi	Bicolor lovegrass	328.	1.	4.
23	Erch	Boer lovegrass	192.	0.	1.
24	Agcr	Crested wheatgrass	36.	112.	85.

(Fall Seeded - Sept. 9, 1963)

			6/6/64	8/20/64
1	Agcr	Crested wheatgrass	172.	46.
2	Elju	Russian wildrye	424.	167.
3	Agin	Intermediate wheatgrass	275.	190.
4	Agsi	Siberian wheatgrass	214.	283.
5	Agtr	Pubescent wheatgrass	441.	263.
6	Elci	Giant wildrye	30.	5.
7	Eula (SS1-62)	Winterfat	0.	0.
8	Eula	Winterfat	1.	0.
9	Orco	Blue ricegrass	63.	40.
10	Orhy (4406)	Indian ricegrass	94.	82.
11	Orhy (3763)	Indian ricegrass	33.	17.
12	Orhy	Indian ricegrass (Red Desert)	29.	13.
13	Stor	Mandan ricegrass	5.	1.
14	Sihy	Squirrel Tail (Springerville)	153.	27.
15	Agin (Amur.)	Intermediate wheatgrass (Amur)	191.	109.
16	Agtr (4302)	Pubescent wheatgrass	255.	121.
17	Agsm	Western wheatgrass	80.	56.
18	Agin (2788-25)	Intermediate wheatgrass	525.	221.
19	Sami (2741)	Burnet	1.	1.
20	Atca (4348)	Four-wing saltbush	9.	8.

Table 23. The species planted in observation plots at Fredonia in 1964.

Summer Seeded		Fall Seeded	
Plot No.	Species	Plot No.	Species
1	Agropyron tricophorum (Luna)	1	Agropyron tricophorum
2	Bouteloua gracilis (stock)	2	A. crestatum
3	B. gracilis A-12424	3	Kangaroo Valley Rye
4	B. curtipendula A-3603	4	A. intermedium A-12496
5	B. eriopoda	5	A. intermedium (Amur) 6
6	Eragrostis lehmanniana A-14107	6	" " (Greenar)
7	E. bicolor A-1415	7	Eragrostis lehmanniana
8	E. curvula	8	A. tricophorum (Topar)
9	Muhlenbergia porteri A-13273	9	Agropyron sibericum
10	M. wrightii	10	A. inerme (Whitmar)
11	Sanguisorba major	11	A. smithii
12	Tetrachne dregei	12	Stiporyzopsis A-15538
13	Digitaria eriantha	13	Festuca ovina duriuscula var.
14	Leptochloua dubia	14	Elymus juncus
15	Oryzopsis hymenoides A-12242	15	Elymus triticoides
16	" " A-14719	16	Oryzopsis hymenoides A-12242
17	" " A-16503	17	" " A-14719
18	Sporobolus airoides	18	" " A-16503
19	S. contractus	19	Bouteloua gracilis A-12424
20	S. cryptandrus	20	Sporobolus contractus
21	S. usitatus	21	S. cryptandrus
22	S. flexuosus	22	Menodora scabra
23	Andropogon ischaemum	23	Purshia glabrata
24	Atriplex canescens	24	Atriplex canescens
25.	Sanguisorba minor	25	Sanguisorba minor

1962 Seeding: Inadequate precipitation prevented almost all germination and emergence from the 1962 summer seeding. Only a small number of plants emerged from the late fall seeding.

A fair emergence resulted from the 1963 precipitation. Those species which have performed best according to the plant counts in 1963 and 1964 (Table 21) were spike dropseed, sand dropseed, Siberian wheatgrass, pubescent wheatgrass, intermediate wheatgrass, crested wheatgrass, Russian wildrye, and western wheatgrass. Four-wing saltbush and burnet have both grown well on this site; however, neither species was abundant.

1963 Seeding: From the observation plots seeded in 1963, excellent emergence was obtained. Briefly, the following results are indicated from Table 22.

(1) The three grama grasses were well established by August 20, 1964. (Figure 13).

(2) Fair to excellent stands were obtained from Indian ricegrass.

(3) Excellent stands of spike muhly and the Sporobolus species developed (Figures 14 and 15).

(4) The Eragrostis species emerged well but they were subsequently winter killed.

(5) The summer seeded crested wheatgrass produced a good stand which appeared better than the fall seeded. All Agropyron species have performed well (Figures 16 and 17).

(6) Burnet and four-wing saltbush grew rapidly and some of the saltbush plants were three feet high by August, 1964 (Figure 18 and 19). Winterfat has not been successfully established on any of the species adaptation plots.

Figure 13. Side-oats grama in the 1963 summer-seeded observation plot as observed August 18, 1964.

Figure 14. Spike muhly in the 1963 summer-seeded observation plot as observed on August 18, 1964.

Figure 15. Sand dropseed in the 1963 summer-seeded observation plot as observed on August 18, 1964.

Figure 16. Pubescent wheatgrass in the 1963 fall-seeded observation plot as observed August 18, 1964.

Figure 17. Siberian wheatgrass in the 1963 fall-seeded observation plot as observed August 18, 1964.

Figure 18. Burnet in the 1963 summer-seeded observation plot as observed August 18, 1964.

Figure 19. Four-wing saltbush in the 1963 summer-seeded observation plot as observed August 18, 1964.

Table 23 lists the species seeded in 1964 but no data have been established yet.

Fertilizer Studies on Seedling Establishment:

Fertilizer was drilled with crested wheatgrass seed in 1962, 1963 and 1964. The design of this study included the following:

2 fertilizers (ammonium nitrate and ammonium phosphate)

4 rates (0, 7, 15 and 30 lbs. of nitrogen per acre)

2 seasons of planting (summer and fall)

2 seedbeds (plowed and brushchopped)

3 replications of each treatment (4 replications - 1962 area).

Each plot was approximately 20 feet wide and 300 feet long (extending over two different seedbeds).

The 1962 Seeding: The 1962 seeding was severely damaged by rabbits in the late spring and early summer months of 1963 because it was not fenced. Plant counts were made on this seeding in 1963 and 1964 and are included in Table 24. These data from the counts indicate only a poor to fair stand on all plots of which those with fertilizer treatments had the poorest stand. No conclusions should be made from these data due to the severe damage by rabbits. The data may be useful, however, for comparison with subsequent studies. The non-fertilized plots had the highest number of plants which might indicate that the rabbits preferred fertilized plants.

The 1963 Seeding: The 1963 study was under a rabbit-proof fence. The data obtained from plant counts from this area indicate very little difference in the stand due to different fertilizer treatments (Table 25). It is of particular interest to note again that the non-fertilized plots, in general, had the best stand. These data also indicate a greater number of plants in

Table 24.
The average number of crested wheatgrass plants per 100 square feet from seed drilled with various amounts of fertilizer in 1962 at Fredonia.

Fertilizer	Rate lb. of N per acre	Date of Counting 6/5/63	8/28/63	8/7/64
		(Summer seeded - July 1962)		
Ammonium nitrate	0.0	39.	13.	30.
	7.5#	24.	12.	23.
	15.0#	30.	20.	26.
	30.0#	15.	12.	22.
Ammonium phosphate	7.5#	20.	12.	20.
	15.0#	24.	13.	20.
	30.0#	15.	8.	19.
		(Fall seeded - October 1962)		
Ammonium nitrate	0.0	8.	4.	38.
	7.5#	7.	2.	16.
	15.0#	4.	3.	14.
	30.0#	9.	2.	19.
Ammonium phosphate	7.5#	8.	2.	20.
	15.0#	7.	3.	15.
	30.0#	4.	2.	12.

Table 25.
The average number of crested wheatgrass plants per 100 square feet on plots drilled with seed and various amounts of fertilizer in 1963 at Fredonia.

Fertilizer	Rate lb. of N per acre	Date of Counting 9/2/63	6/17/64	8/8/64
		(Summer seeded - July 1963)		
Check	00.	63.	130.	108.
Ammonium nitrate	7.5	38.	119.	93.
	15.0	36.	108.	113.
	30.0	54.	90.	95.
Ammonium phosphate	7.5	53.	95.	98.
	15.0	65.	102.	106.
	30.0	31.	101.	111.
		(Fall seeded - September 1963)		
Check	00.	-	232.	231.
Ammonium nitrate	7.5	-	151.	154.
	15.0	-	208.	213.
	30.0	-	210.	168.
Ammonium phosphate	7.5	-	170.	222.
	15.0	-	242.	205.
	30.0	-	152.	174.

the fall seeded area. No statistical analysis has been made of these data but they do not indicate that fertilizers aid in seedling establishment on sagebrush rangelands. Other data from the literature and from greenhouse studies (Annual Report 1962) coroborate this indication. There might be added vigor or increased forage from such fertilizer applications but these factors were not visably evident.

The 1964 Seeding: The same factors were studied again in 1964. This study area was also enclosed by fencing. Time did not permit, however, a plant count to be made in 1964 on this study.

Climatic and Microclimatic Measurements:

The success of a range seeding is closely related to the amount of available soil moisture. The available soil moisture is in turn affected by the amount of precipitation, the amount of run-off, temperature, and relative humidity. In addition, the temperature and relative humidity directly affect the physiology of germination and the establishment of seedling grasses. The instrumentation being used at Fredonia area to measure these factors are recording-type rain gauges, hygrothermographs, anemometers, Piche atmometers, and thermocouples.

Studies to determine the effectiveness of precipitation are underway. Not all precipitation becomes available for plant growth. Part of the loss is due to run-off. In the absence of conflicting evidence, the water intake rate of the soil on the experimental area is believed to be comparatively high. Run-off has not been observed to be of major consequence from rain-storms on the area.

Data from other factors which decrease the effectiveness of the precipitation are being collected. These factors are relative humidity, air temperatures, wind velocity measurements, relative evaporation rates, and soil temperatures. The average relative humidities and average daily temperatures are in the process of being summarized. The data from the above factors relative to different years of seeding and various seedbeds are as follows:

Wind Velocity Measurements: Wind velocity measurements were taken at 1, 3, and 18-foot heights above the ground level. The 18-foot height was designated as a standard, and the data from the 1 and 3-foot heights were derived as a percentage of this standard. The data were taken from the following seedbeds in 1963 and 1964.

(1) Non-treated having living sagebrush plants.

(2) Herbicide sprayed having standing but non-living sagebrush plants

(3) Brushchopped having all shrubs removed at the ground level

The 1963 data were presented in the Progress Report for that year. The data obtained in 1964 are presented in Figure 20 and they are similar to those from 1963. Whereas, the trend indicated by these data was as expected, their main value was to indicate the magnitude of the differences in wind velocity over the various seedbeds. From Figure 20, the wind velocity at the one-foot level was estimated to be 100% greater in the herbicide sprayed plots than in the non-treated standing sagebrush plots. At the three-foot height there was very little difference. The wind velocity at the one-foot height on the cleared seedbed was estimated to be 230% greater than that on the non-treated standing sagebrush. At the three-foot height, this difference between the non-treated and cleared seedbeds was about 35%.

These estimations point out the magnitude of protection from dessicating winds for seedlings growing in herbicide sprayed areas. There is considerable

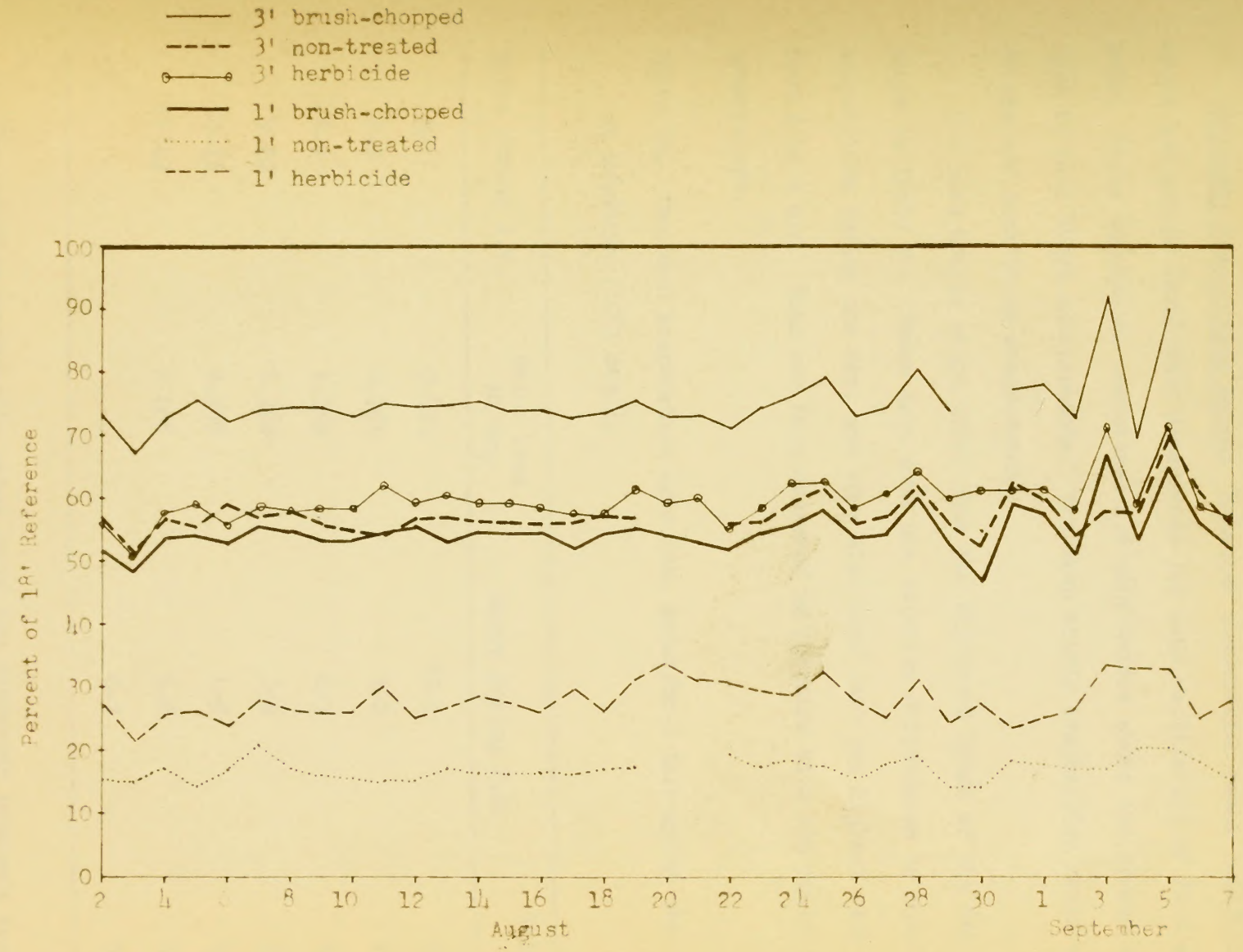


Figure 20. Daily wind velocity at 1 and 3 feet heights above the ground surface for three different seedbeds in terms of percentage of the reference height of 18 feet.

wind throughout the year at the Fredonia area which contributes to the aridity of the range reseeding site.

Relative Evaporation Rates: Relative evaporation rates immediately above the ground level were determined for each replication of five seedbeds. Piche atmometers positioned 2.5 centimeters above the ground were used to make these measurements. The mean hourly evaporation rates were determined from these measurements.

The mean hourly evaporation rate for different hours of the day is shown in Table 26. These data show the relative differences in hourly evaporation during the day, and they also show that the highest rate occurs from 1 to 2 p.m. This has been observed to coincide with the daily maximum temperature.

Table 26. The mean evaporation rate (mm. water/hr.) throughout the day at Fredonia (1963 data).

Hours during A.M.	Water loss in mm.	Hours during P.M.	Water loss in mm.
6-7	0.431	12-1	1.699
7-8	0.761	1-2	1.767
8-9	1.069	2-3	1.694
9-10	1.356	3-4	1.483
10-11	1.575	4-5	1.292
11-12	1.468	5-6	0.961
		6-7	0.781

The relative evaporation rates among the different seedbeds are shown in Table 27. The rate of evaporation was significantly greater on the chopped

and plowed seedbeds in comparison with non-treated, herbicide sprayed, and chopped-pitted seedbeds. The reasons for this significance are not evident at this time. As previously discussed, the wind velocity is decidedly lower on the non-treated and herbicide sprayed seedbeds, which would account for their lower evaporation rates. But, no explanation can be offered to explain why chopped-pitted seedbed has less evaporation than the plowed seedbed.

Table 27. The mean relative evaporation rate (mm. water/hr) from five different seedbeds. All figures underscored by the same line indicate no significant difference when tested at the 5 percent level (1963 data from Fredonia).

	Seedbeds				
Factor Measured	Non-Treated	Herbicide	Chopped-Pitted	Chopped	Disk Plowed
Water loss in mm.	1.069	1.136	1.300	1.372	1.405

Evaluations on Pest Control:

Two of the major pests in experimental range seedings on sagebrush rangelands are ants and rabbits. It is difficult to determine quantitatively the damage caused by ants, but it is known from visual evaluations that they can harvest and store large quantities of seed. No herbaceous seeded plants became established around their mounds because of this reason. The damage caused by rabbits is very evident as illustrated by the photograph in Figure 21.

Exclosures were used to evaluate rabbit damage. The site shown in Figure 21 was seeded in 1962 with crested wheatgrass which became established only because of protection from rabbits. In addition to exclosures, salt poisoned with strychnine was used for rabbit control. Although considerable rabbit damage was apparent on the 1963 seedings, very little damage was

noticeable on the 1964 seedings. This is believed to be due partially from the intensive rabbit poisoning program conducted over the experimental area. It has been observed that grass plants grazed by rabbits have remained alive, but these plants do not have the vigor or maturity of those plants having protection.

Ants were controlled during the 1964 season with Mirex Ant Bait. It is estimated that 80 to 90% control was obtained with this poison. The poison was applied at the rate of five pounds of bait per acre. The use of these pest control measures has contributed to a better understanding of other factors affecting the success of a range seeding. Before any particular factor can be given the proper significance in these studies, other interfering factors must be accounted for or controlled.

Figure 21. A rabbit exclosure on a crested wheat plot drilled in 1962.

A TERMINAL REPORT ON PELLETED VS. NON-PELLETED SEEDS FOR SEEDING RANGELANDS IN ARIZONA

Under a cooperative agreement between the Bureau of Land Management and the University of Arizona, research was conducted by the University to evaluate the effectiveness of pelleted seed for seeding rangelands. In accordance with this agreement, four range areas characteristic of the Bureau's grazing land in Arizona were selected for intensive study with pelleted seed. These study sites were located near Cordes, Congress, Safford, and Fredonia, Arizona. A research program was developed having the following objectives:

(1) To determine the effectiveness of earthen-pelleted seed for seeding rangelands under various seedbed preparations and seeding methods.

(2) To evaluate the response of pelleted seed under various edaphic and climatic conditions.

(3) To compare the aerial broadcasting of pelleted seed against conventional range seeding methods using non-pelleted seed.

(4) To evaluate those characteristics of the pellet per se which might affect seed germination and seedling establishment.

The field studies were begun in 1961 at Cordes and Congress and in 1962 at Safford and Fredonia. The studies were continued through 1962 and 1963 at Congress and through 1963 at Safford and Fredonia. The results from each area for each year of planting have been covered in progress reports previously submitted. Likewise, the experimental procedures and treatments are covered in detail in previous reports. These studies were terminated under the previously mentioned agreement as of June 30, 1963. This is a terminal report in the respect that it covers the final plant couhts made in 1964 on

all areas and years of study. A comprehensive report for publication is currently being prepared.

The Cordes Area

The Cordes Area was chosen with particular respect to two of the major advantages claimed for pellet seeding; i.e. (1) the need for seedbed preparation and seed coverage is eliminated by the use of pelleted seed, and (2) areas too steep and/or rocky to seed with conventional ground equipment can be aerially seeded with pelleted seed. Therefore, pelleted and non-pelleted seed of Lehmann and boer lovegrass were aerially seeded in this area in 1961. The data taken in 1964 from this area are presented in the following Table A1.

Table A1. The average number of plants per 100 square feet in the Cordes Area from seeding pelleted and non-pelleted seed of Lehmann and boer lovegrass in 1961

Species	Seed Treatment	
	Pelleted	Non-Pelleted
Lehmann lovegrass	5.5	4.4
Boer lovegrass	2.9	1.5
Mean	4.2	2.9

Observations since 1961 until 1964 have indicated an increase in the lovegrass plants since the very poor emergence from the 1961 seeding. This increase occurred generally as rather uniformly distributed but widely spaced individual plants with an occasional densely populated island ranging in size from a few to several hundred square feet. The larger number of plants of the 1964 establishment occurred as islands of plant groups which indicates that these plants come from the seed of previously established plants and

not from the seed sown in 1961. No significance should be attached, therefore, to the difference in the number of plants arising from pelleted or non-pelleted seeded plots. Of pertinent significance at this point is the fact that pelleted seeds were ineffectual in promoting a successful range seeding.

The Congress Area

Pelleted seeding studies were conducted for three years in the Congress Area (1961, 1962 and 1963). Pelleted and non-pelleted seeds were broadcast and drilled on various seedbed preparations.

The 1961 Seeding: The only plants emerging from the 1961 seeding were in pitted and drilled plots, and these plants were too scarce for significant evaluation of the seeding. These plants subsequently died; therefore, the seeding was judged a failure at the end of the 1961 season.

During 1963, favorable rainfall conditions prevailed and a fair stand of grass emerged from the 1961 seeding. This was due to the delayed germination of the Lehmann and boer lovegrass seeded in 1961. This stand occurred on the pitted seedbeds which were drilled with both pelleted and non-pelleted seed. A statistical analysis of the number of plants emerged at this time showed that the stand from non-pelleted seed was significantly better. Nevertheless, this stand was not established sufficiently to withstand subsequent drought conditions and the entire stand was lost. No plant counts were made, therefore, during 1964.

The 1962 Seeding: Pelleted and non-pelleted seed of black grama, boer lovegrass, and Lehmann lovegrass was seeded again in the Congress range area in 1962. Again, a very poor stand was obtained. The only species to become established was Lehmann lovegrass, and establishment occurred only in the

cleared-pitted plots which were drilled with non-pelleted seed. No seedlings were found on any of the other treatments.

Under the favorable rainfall pattern of 1963, the stand from the 1962 seeding increased. The data from the plant counts made in 1963 and 1964 are presented in Table A2 for the 1962 seeding. These data illustrate that a very poor stand was obtained; and therefore, the data therefrom were not suitable for statistical analysis. Nevertheless, the following trends are indicated from these data.

Table A2. Average number of plants per 100 square feet on various seedbed treatments seeded with pelleted and non-pelleted Lehmann and boer lovegrass seed at Congress in 1962.

Seedbed Preparation and Seeding Method	Year of Count	Species and Seed Treatment			
		Boer Lovegrass		Lehmann lovegrass	
		Pelleted	Non-Pelleted	Pelleted	Non-Pelleted
No Treatment-Broadcast	1963	0.0	1.5	2.8	62.3
	1964	0.0	1.3	0.0	2.3
Cleared-Broadcast	1963	9.5	11.8	2.3	70.8
	1964	0.0	4.0	1.2	15.3
Cleared-Pitted-Broadcast	1963	8.3	11.0	6.0	80.8
	1964	0.3	0.0	2.3	13.8
Cleared-Pitted-Drilled	1963	16.3	34.5	16.5	51.3
	1964	2.0	3.3	5.5	20.3

A better emergence and establishment is noted from non-pelleted seed. It is noted also that the better the seedbed preparation, the better the resulting stand. Lehmann lovegrass was considerably better adapted to the environment of Congress than boer lovegrass.

The 1963 Seeding: Pelleted and non-pelleted Lehmann lovegrass seed was sown in the Congress area in 1963. The results from this years seeding are thoroughly discussed in the 1963 progress reports.

Table A3. The survival of Lehmann lovegrass plants in 1964 with respect to method of seedbed preparations and seeding methods conducted in 1963 at Congress. Data are the average number of plants per 100 square feet for all replications of both pelleted and non-pelleted seedings.

Seedbed Preparation and Seeding Method	Establishment (1963)	Survival (1964)	Percent Survival
No Treatment-Broadcast	50.	7.	14.8
Cleared-Broadcast	46.	18.	40.2
Cleared-Pitted-Broadcast	294.	54.	18.3
Cleared-Pitted-Drilled	389.	39.	10.0

As was brought out in the 1963 progress report, non-pelleted seed was much more effective for range seeding than pelleted seed. The same conclusions were supported from the 1964 plant count. The data from the 1964 count, however, point out an additional factor which is illustrated in Table A3. The unusually dense stand resulting from the 1963 seeding set up a severe inter-plant competition during subsequent drought periods. The heaviest stand in 1963 suffered the greatest reduction in plant numbers in 1964. Despite the high percentage of plant loss, the surviving stand in the cleared and pitted treatments is two or three times greater than the non-treated or non-pitted treatments.

The Safford Area

Pelleted seeding studies were conducted near Safford, Arizona, during 1962 and 1963. In 1962, both Lehmann and boer lovegrass were seeded; whereas, only Lehmann lovegrass was seeded in 1963.

The 1962 Seeding: The results from the 1962 seeding are covered in the progress report of 1962. These results showed that non-pelleted Lehmann lovegrass seed drilled into cleared and pitted seedbeds produced the best stand.

Although the stand has decreased in number of plants since the seeding in 1962, the data from the 1964 plant count still support the above conclusion that the drilling of non-pelleted seed is the most effective seeding method. These data are presented in Table A4. While it can be noted that the stand from the broadcasted, pelleted seed has a few more plants than the stand from the broadcasted non-pelleted seed, this difference is less than three plants per 200 square feet which is not significant.

Table A4. The average number of plants per 200 square feet established due to seeding pelleted and non-pelleted Lehmann and boer lovegrass on various seedbeds at Safford in 1962. Data were taken in Sept. 1964.

Seedbeds and Methods of Seeding	Pelleted		Non-Pelleted	
	Lehmann	Boer	Lehmann	Boer
Broadcasted				
No preparation	0.0	0.0	0.0	0.0
Cleared	2.0	2.75	0.0	0.25
Cleared and Pitted	3.25	3.00	0.50	0.75
Drilled				
Cleared and Pitted	6.25	4.00	26.25	7.75

The 1963 Seeding: During 1963 there were no instances where pelleted seed was more effective in stand establishment than non-pelleted seed. In fact, the drilling of non-pelleted seed produced the significantly better stands. The plant counts taken in 1964 also supported the above conclusions. These data from the 1964 counts are presented in Table A5.

Table A5. The average number of plants per 200 square feet from seeding pelleted and non-pelleted seed of Lehmann lovegrass on various seedbeds at Safford in 1963. Data were taken in Sept. 1964.

Seedbeds and Method of Seeding	Seed Treatment	
	Pelleted	Non-Pelleted
Broadcast		
No preparation	0.0	0.02
Cleared	0.35	0.42
Cleared and Pitted	0.52	0.82
Drilled		
No preparation	0.0	0.15
Cleared	0.25	1.37
Cleared and Pitted	0.62	2.52
Mean	0.29	0.88

The Fredonia Area

Studies on pelleted seed as a means of seeding sagebrush rangelands were conducted near Fredonia in 1962, and 1963. In 1962, pelleted and non-pelleted seed of blue grama and crested wheatgrass was sown in July, and similarly treated seed of crested wheatgrass and Russian wildrye was sown in October. These seeds were both aerially broadcast and drilled into four seedbeds ranging in preparation from non-treated to brushchopped, chopped-pitted and wheatland plowed. In addition, all of the above treatments were conducted on two areas - the primary area and the secondary area.

Due to inadequate precipitation, there was no emergence from any of the seedlings made in 1962. The favorable moisture regime during 1963, however, brought about the emergence of many seedlings from both the summer and fall

seeding on both areas. A plant count of this emergence has previously been reported in the 1963 Progress Report. During 1964 the final plant count was made on the 1962 seeding. In nearly every plot sown with pelleted seed there were very few or no established plants. Thus, there were no data from many of the plots which precluded statistical analysis. The fact that non-pelleted seed was much more effective for seeding either by broadcasting or drilling on all seedbeds is illustrated in Tables A6 and A7.

The studies with pelleted seed were continued in 1963 with the same seeding variables as used in 1962 excepting that only the primary area was seeded and only blue grama was seeded in the summer. For the fall seeding, both crested wheatgrass and Russian wildrye ware seeded.

The emergence from the 1963 seeding was good excepting from those plots seeded with pelleted seed. This seeding was counted in 1964 and the results therefrom are very similar to those obtained from the counting made in 1963. That is, the use of palleted seed was not an effective method for range seedings. The results from a statistical analysis of the overall data from the 1964 count are presented in Table A8.

Table A8. The mean number of plants per 100 square feet from the pelleted and non-pelleted seed of three species sown by drilling and aerial broadcasting in 1963. Data were taken in 1964 at Fredonia, Arizona.

Species	Seed Treatment			
	Non-Pelleted		Pelleted	
	Drilled	Aerial Broadcast	Drilled	Aerial Broadcast
Blue grama	178.	8.*	4.*	1.5*
Crested wheatgrass	256.	44.	12.	1.6
Russian wildrye	143.	14.	6.	0.4

* All values underscored by the same line in each row are not significantly different when tested at the 5% level.

Table A 6.
Results from the 1964 plant counts of the July 1962 seeding on the Arizona Strip. Values are the mean number of plants per 100 square feet of various seedbeds with pelleted and non-pelleted seeds.

Seedbeds and Seeding Methods		Primary Area		Secondary Area	
		Non-pelleted	Pelleted	Non-pelleted	Pelleted
Drilled Plots					
Crested Wheatgrass					
Seedbed:	Chopped	22.75	1.00	49.75	2.75
	Chopped-pitted	17.75	2.00	75.25	1.50
	Wheatland plowed	13.50	1.00	68.25	2.75
Blue grama					
Seedbed:	Chopped	2.75	0.25	99.75*	65.25*
	Chopped-pitted	1.50	0.25	30.00*	36.50*
	Wheatland plowed	2.00	0.00	15.25*	9.50*
Airseeded Plots					
Crested Wheatgrass					
Seedbed:	Non-treated	.00	0.00	4.75	0.00
	Chopped	35.75	0.50	273.50	0.75
	Chopped-pitted	5.25	0.50	220.75	2.50
	Wheatland plowed	6.50	1.25	194.25	2.25
Blue Grama					
Seedbed:	Non-treated	0.00	0.00	29.50*	3.25*
	Chopped	2.50	0.25-	15.50*	10.50*
	Chopped-pitted	1.25	0.25	18.75*	0.50*
	Wheatland plowed	0.00	0.00	8.25*	3.75*

* Native blue grama included in counts
\- Unable to distinguish from seeded plants

Table A 7.
Results from the 1964 plant counts of the October 1962 seeding on the Arizona Strip. Values are the mean number of plants per 100 square feet of various seedbeds seeded with pelleted and non-pelleted seed.

Seedbeds and Seeding Methods	Primary Area		Secondary Area	
	Non-pelleted	Pelleted	Non-pelleted	Pelleted
Drilled Plots				
Crested Wheatgrass				
Seedbed: Chopped	26.33	0.00	46.25	0.50
Chopped-pitted	43.33	0.67	44.75	1.00
Wheatland plowed	0.00	0.00	72.25	3.50
Russian wildrye				
Seedbed: Chopped	36.33	1.33	18.75	1.00
Chopped-pitted	36.67	4.33	24.75	3.25
Wheatland plowed	22.33	1.67	27.50	3.50
Airseeded Plots				
Crested wheatgrass				
Seedbed: Non-treated	0.00	0.00	0.25	0.25
Chopped	13.33	6.67	88.75	2.25
Chopped-pitted	39.00	3.33	143.00	4.75
Wheatland plowed	87.50	13.50	78.00	6.75
Russian wildrye				
Seedbed: Non-treated	0.00	0.33	0.00	0.00
Chopped	15.67	0.67	0.50	1.25
Chopped-pitted	9.33	3.33	2.50	2.25
Wheatland plowed	0.50	15.50	10.75	5.00

Even though only the drilled, non-pelleted seed gave a significant response, the broadcast non-pelleted seed responded uniformly better than the pelleted seed. The contrast in the response from pelleted and non-pelleted seeds is readily visualized from the photograph in Figure A1.

The response from pelleted seed was poor regardless of the species, method of seeding, or the seedbed used in the evaluation. This is further illustrated by the data in Tables A9, A10, and A11.

In summary with respect to all areas and years concerning the use of pelleted and non-pelleted seed, the following conclusions are indicated:

1. Earthen-pelleted seed was not effective for seeding rangelands in Arizona. The response from seeding pelleted seed was very poor whether broadcast or drilled. Furthermore, seeding pelleted seed into various seedbed preparations did not bring about any improvement in stand establishment from pelleted seed.
2. The response from pelleted seed was uniformly poor under the broad spectrum of climatic and edaphic conditions presented at Cordes, Congress, Safford and Fredonia, Arizona.
3. Although the aerial broadcasting of pelleted seed was specifically recommended, conventional range seeding methods using non-pelleted seed was much more effective in seeding Arizona rangelands.
4. The pelleting process appears to be harmful with respect to the germination of the larger seeded range grasses. This reduction in the percentage germination for several pelleted grass seeds is depicted in the following Table A12.

Figure A 1. A contrast between drilled non-pelleted and drilled pelleted blue grama seeded in 1963 on a brush chopped seedbed. The stand on the left was from non-pelleted seed.

Table A 9.
Results from the 1963 and 1964 plant counts from pelleted and non-pelleted blue grama seed sown in July, 1963 on various seedbeds at Fredonia, Arizona. Values are the mean number of plants per 100 square feet.

Seed Treatment, Method of Seeding, and Seedbed	Date Counted 9/8/63	8/25/64
Drilled-Non Pelleted		
Seedbed:		
Non-treated	67.50	41.25
Herbicide sprayed	143.50	89.25
Chopped	352.25	252.25
Chopped-pitted	298.00	183.75
Disk	303.00	189.75
Drilled - Pelleted		
Seedbed:		
Non-treated	0.75	0.00
Herbicide sprayed	2.00	1.50
Chopped	4.75	5.25
Chopped-pitted	4.00	3.75
Disk	19.00	7.50
Airseeded - Non Pelleted		
Seedbed:		
Non-treated	0.00	0.75
Herbicide sprayed	0.00	2.50
Chopped	15.25	47.00
Chopped-pitted	2.75	15.75
Disk	3.50	13.75
Airseeded - Pelleted		
Seedbed:		
Non-treated	0.00	0.50
Herbicide sprayed	0.00	1.00
Chopped	0.00	6.25
Chopped-pitted	0.25	8.25
Disk	0.00	4.50

Table A 10.
Results from the 1964 plant counts from pelleted and non-pelleted Russian wildrye seed sown in September, 1963 on various seedbeds at Fredonia, Arizona. Values are mean numbers of plants per 100 square feet.

Seedbed Preparation	Pelleted		Non-Pelleted	
	Drilled	Airseeded	Drilled	Airseeded
Non-treated	0.50	0.00	34.00	0.00
Herbicide sprayed	2.50	0.00	86.50	0.50
Chopped	15.00	0.25	170.75	14.75
Chopped-pitted	4.50	0.50	152.50	43.75
Disked	9.00	1.75	171.00	19.50

Table A 11.
Results from the 1964 plant counts of pelleted and non-pelleted crested wheatgrass seed sown in September, 1963 on various seedbeds at Fredonia, Arizona. Values are mean number of plants per 100 square feet.

Seedbed Preparation	Pelleted		Non-Pelleted	
	Drilled	Airseeded	Drilled	Airseeded
Non-treated	04.00	0.00	16.75	8.00
Herbicide sprayed	13.50	0.00	88.75	4.50
Chopped	16.75	9.00	74.75	86.00
Chopped-pitted	19.50	2.75	84.25	64.00
Disked	18.25	2.25	72.25	56.00

Table A12. The number of seeds per pellet and the comparative germination of the pelleted seed of six species of range grasses.

Species	Number of seeds per pellet		Percent Germination		Change in Percent Germination
	Range	Average	Non-pelleted	Pelleted	
Lehmann lovegrass	30-82	57.5	38.0	36.0	-5.3
Boer lovegrass	19-79	47.2	86.0	88.0	+2.3
Black grama	0-7	0.94	96.0	41.0	-57.3
Blue grama	11-41	23.6	44.0	9.6	-78.0
Crested wheatgrass	2-20	8.6	56.3	16.1	-71.4
Russian wildrye	2-15	7.0	79.3	28.0	-64.6